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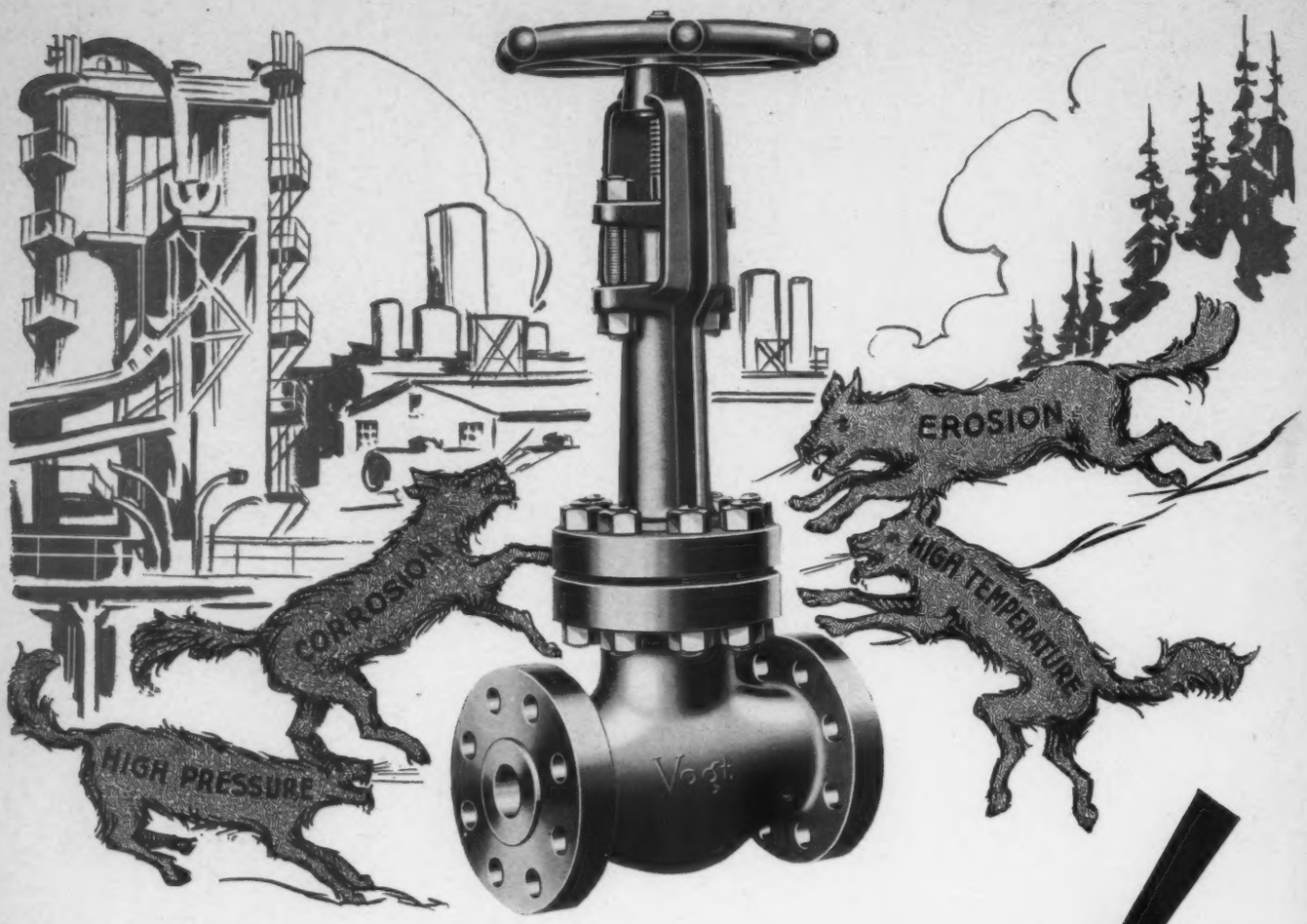


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# REFINER
## AND NATURAL GASOLINE MANUFACTURER

JANUARY, 1934
Vol. 13, No. 1

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**GRADY TRIPLETT**
***Editor***

**GEORGE REID**
***Associate Editor***


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J. KENT RIDLEY, *Managing Editor*

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VOLUME 13, No. 1 JANUARY, 1934

# *The Role of the Small Plant . . .*

THROUGH the pooling agreement now under consideration by Harold L. Ickes the refining industry has agreed to accept a penalty for the building of an excessive plant capacity. In simple terms it amounts to a willingness to buy fifteen million barrels of gasoline and withhold it from the market for a definite period under fixed conditions.

That excess of motor fuel is to some extent the fruit of building plants sufficient to provide or even surpass distribution through sales outlets. The larger integrated concerns adopted that attitude several years back. Each was determined to make each gallon of its gasoline in its own plants. That fact made good copy for newspaper advertising but otherwise contributed nothing to the individual company.

The policy was adopted despite the knowledge that smaller concerns are prone to build plant capacity wherever opportunity abounds. When the East Texas field was under development along came the small refining plants. But that part of the industry with the retail outlets under its control was not in position to take advantage of these small refining plants.

So the pooling agreement is simply a recognition of the necessity for buying a part of current supply in the open market. If the plan is approved it still will not have the benefits that would have come through buying because the gasoline could be used. It must be bought because it threatens a market. Had the integrated concerns provided smaller plant capacity, the gasoline in East Texas or elsewhere could have been taken in smaller amounts as needed and a better balance held in the gasoline market.

Open market speculation in gasoline should be permanent policy. It affords opportunity for profit. Supplies can be bought in winter against sale in summer. Several concerns followed the practice over a long period and the results were satisfactory. One that comes to mind never contemplated plant capacity equal to sales needs. Plant capacity was not sufficient to provide gasoline for the summer months. Buying was at its best in the winter. But that concern is now a part of a gigantic combine and its policy has changed. Instead of capacity slightly below needs it has capacity slightly in excess of needs and its name is on the list of those proposing the pool.

Open market speculation also should involve selling gasoline as the need arises. A market that promises to get out of bounds can thus be held in check. Wise buying and wise selling should be the two courses followed for keeping markets in line.

It will not suffice to justify excessive plant capacity by ignoring the independent plants. Perhaps they should not be built. That is only theory. The fact is that such plants are built. They are built each time a big oil field provides raw material. They can not be ignored because they exist. Few of those in East Texas or at Oklahoma City can be accepted as permanent. But while they exist the larger concerns should take them into account and recognize that others will be built as crude oil will allow the building.

Nothing can be done to alter present conditions. Fortunately plant capacity is not stable. All manner of plants give way before heat. As fire and corrosion reduce plant capacity the industry should rebuild with the small plant a recognized factor. Instead of damning it as a wrecker of markets it should be used in a way to stabilize the market.

# Continental's . . *Denver Refinery*

## EXAMPLE OF Complete Electrification

CONTINENTAL OIL COMPANY'S refinery at Denver, Colorado, is outstanding in its compact arrangement and its use of electricity. In fact, it might be called the "electrical refinery" for electricity has been incorporated in the design of this plant to such an extent that it is difficult to think of another use where it might be employed.

The plant is a 2000-barrel Kellogg combined skimming and cracking plant, using two 14-ton capacity Gray vapor phase towers for cracked gasoline, with absorber and stabilizer in combined unit (Figure 1).

At this plant is processed gasoline, kerosene, fuel oil and furnace distillate. It has a storage capacity of 165,000 barrels crude, 75,000 barrels finished gasoline and 30,000 barrels fuel oil.

Crude on which the plant operates is shipped in by tank cars from Salt Creek, Wyoming, Craig, Colorado, the Osage Field, near Laramie, Wyoming, and from Fort Collins and Orchard, Colorado.

The plant is situated just outside the Denver city limits on the Brighton road, and if you should visit the plant at night you would be impressed by the bold relief in which it stands out from the surrounding darkness of the landscape, for this Conoco plant practically basks in daylight the whole 24 hours of the day. 18,000,000 candle power of electric light from 13 giant flood lights pours over the refinery from 55-foot steel towers and presents one of the most impressive sights of modern industry and the use of electricity. The fact that refinery operation is a 24-hour business has been well recognized here in giving it the advantage of adequate lighting during all hours.

As one enters the main gate and admires the vast expanse of perfectly kept green lawns and shrubbery, the spick and span appearance of all tanks, equipment, grounds and roadways, perhaps the next unusual thing to strike his attention is the substantial looking electric power substation, for here is the beginning of the outstanding feature of the plant—electricity.

Electric power has been so featured that the use of steam is insignificant. A small steam boiler of 125 horsepower is used to heat the buildings, the eight employees' bungalows and for steaming out tank cars and drums. With this, steam heat has practically completed its work. All oil and water pumps, air compressor, water wells, fans, blowers, mixers, control gauges and instruments and control valves on pumps in the cracking units are electrically operated.

Power of 13,200 volts is delivered to the company's substation by Colorado Central Power Company from its plant at Valmont (near Boulder), Colorado, about 30 miles away. A unique arrangement in this power hook-up is that two main power lines enter the refinery substation—one from the south and one from the north. This is a protective arrangement against interruption as there is in operation at the substation an automatic time relay switch which, should power be cut off from one line, automatically throws the other line in after seven seconds delay. The refinery has 1200 horsepower connected load with a continuous load of 600 horsepower.

The administration building is outstanding because it not only houses the superintendent's office and laboratory, but also the control room of all refining units and the boiler and air compressor equipment as well. The plan shown in Figure 2 gives an idea of this arrangement. The superintendent has a clear view through large steel sashed windows from his desk into the laboratory, control room and boiler house. In the boiler room is also housed the 40 cubic feet per minute capacity automatic air compressor operated by a 125 horsepower motor.

With the use of electricity at this plant, fewer men are needed than at most plants of its size. Before the NRA code was adopted, the entire plant force, includng the superintendent, consisted of 18 men. The plant now employs 24 men as follows:

Superintendent, 15 men directly connected with operation, two clerks, one chemist, one mechanical foreman, four laborers.

The refinery water supply comes from two 25-foot wells of 350 gallon per minute capacity each, in the plant yard. Circulating water amounts to 900 gallons per minute and 125 gallons per minute make-up water is required. These water wells are equipped with vertical Coniflo pumps direct connected to electric motors. A deep artesian well furnishes water for drinking purposes and for use at the employees' houses.

At the cooling tower pump house there are in op-

ELECTRICITY IN REFINERY OPERATION

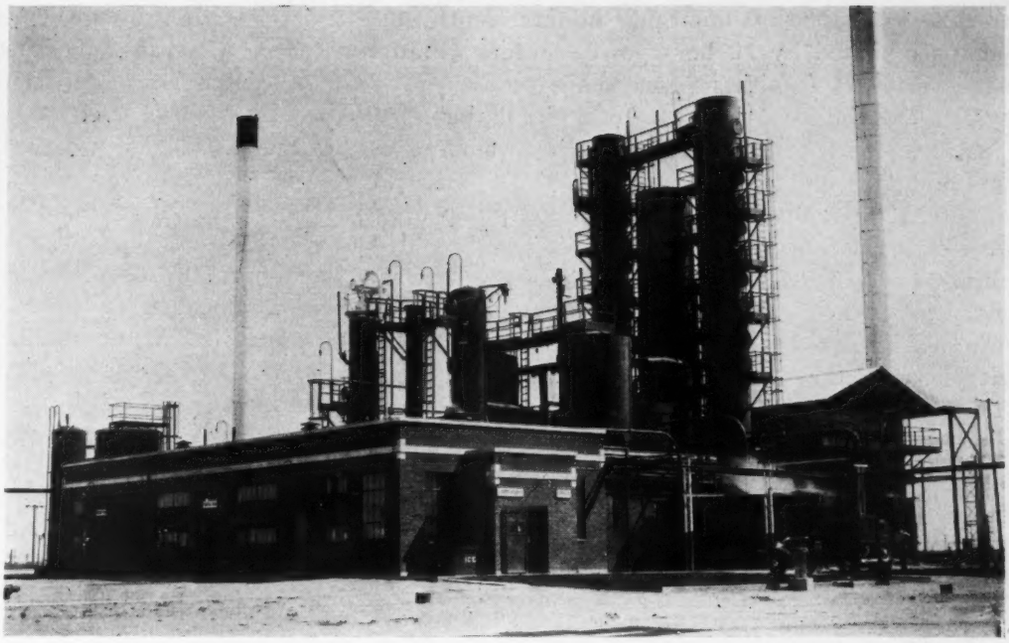


**FIGURE 1**

*Administration building with main refining units in background.*

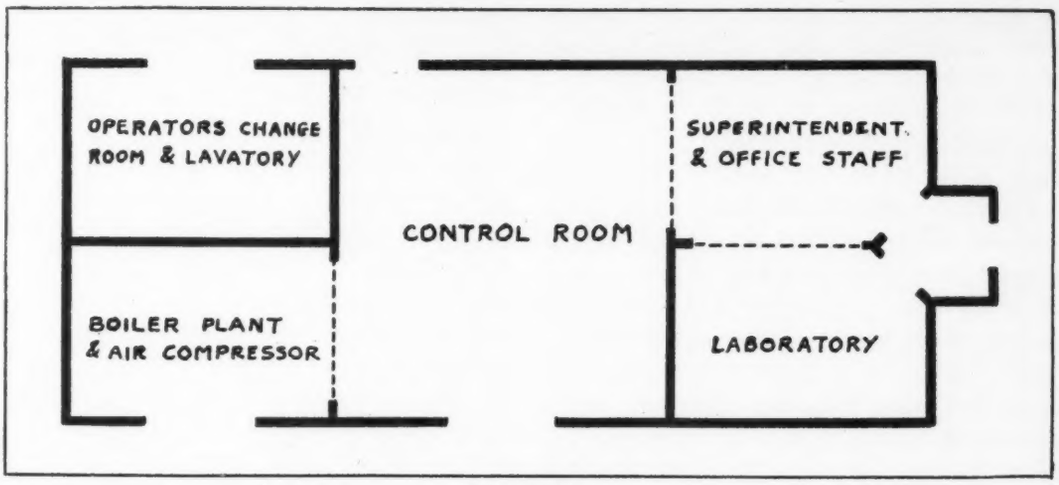



**FIGURE 2**

*Plan of administration building, control room and boiler house.*

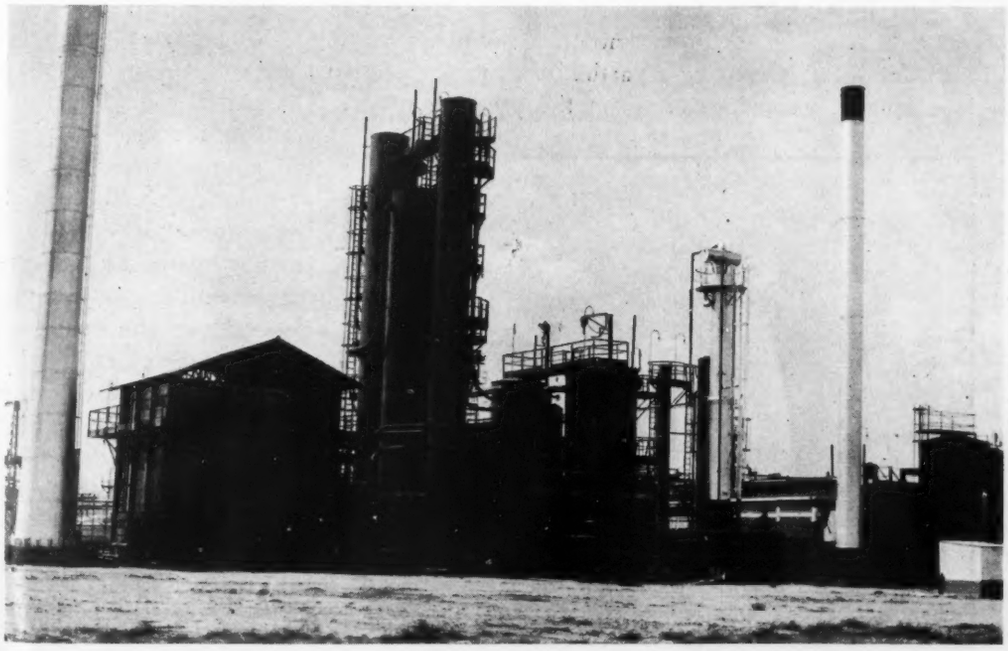


**FIGURE 3**

*Kellogg Cracking Plant; stabilizer in the right background.*

eration two 1000 gallons per minute centrifugal pumps operated by 50 horsepower motors (Figure 4). One pump furnishes water to the refinery water system and the other is for tower recirculation.

Also installed at this pump house is an emergency fire pumping unit consisting of a 1000 gallons per minute, 150 pounds pressure centrifugal pump operated by a Sterling six-cylinder gasoline engine. This engine can be started at the touch of a button at the plant superintendent's office several hundred yards away. Fuel for this engine is stored in a 40-gallon electric welded steel tank installed outside the pump house and pipe connected to the engine by one-inch pipe.

A stabilizer tower with overhead propane take-off has just been completed. The finished gasoline from stills is rerun through this tower to depropanize and control the vapor pressure on the finished gasoline stream.

Another interesting installation recently completed is the Ethyl storage and mixing tank. With this unit in operation greater efficiency and safety will be effected in the Ethyl handling and mixing operation.

The laboratory is characterized by its compact arrangement of latest testing equipment.

To the east of the plant the company has built eight modern brick bungalows for employees. They are fully equipped with electrical appliances including electric ranges and refrigerators.

The use of electricity at this plant has resulted in efficient operation both from a mechanical and financial standpoint. Under the management of plant superintendent J. E. Fenex, this plant presents an atmosphere and appearance that might be termed ideal to the refining world. The absence of mechanical grief, fire hazards, inefficient and costly layouts makes it a model plant. One has the impression upon visiting this Denver refinery of Continental Oil Company that it operates almost like an electric clock.

The processing unit of Continental Oil Company plant at Denver, Colorado, is compact, occupying a space only 85 feet wide by 128 feet in length. This area is covered by the skimming, cracking, boiler room, control room, laboratory and office, together with other necessary equipment. Tankage for crude and refined products, treating, loading, pumping and other equipment occupy others portions of the plot of ground.

The plant was designed jointly by the engineers in the refining department of Continental Oil Company and the engineers of M. W. Kellogg Company. It consists of a modified Cross combination cracking and skimming unit with a capacity of 2000 barrels of cold raw crude through-put each day. The furnace is a Kellogg radiant heat unit containing 157 tubes divided into two sections—cracking and reboiling. Skimming is accomplished by heat exchange and consequently the raw cold crude does not enter the tubes of the furnace. Fourteen tubes are installed on the face of the bridge wall, 18 on the outside wall, 45 tubes in two rows are placed in the roof for the absorption of radiant heat, and 80 tubes are installed in the vertical bank behind the bridge wall for the absorption of convection heat. Eight tubes in the two top rows, or shield section of the convention bank, the bridge and side wall tubes, the roof tubes and 24 tubes of the convection section immediately below the eight shield tubes, are utilized in cracking service. Forty-eight tubes in the convection section are used for reboiling the bubble tower bottoms. Firing of the furnace is from both ends of the combustion chamber through Coen combination gas and fuel oil burners. Draft for the furnace is accomplished by a steel stack, 145 feet high, self supporting, and lined throughout its height with brick.

The evaporator tower is eight feet in diameter by 47 feet eight inches in height, and contains four bubble decks and three "disc and doughnut" baffles. In the top of the tower, just above the top bubble tray is a pancake coil through which the fresh crude is preheated before it enters the flash tower. Beneath this pancake coil, and between it and the top bubble tray, is a draw-off pan which collects the gas oil condensed as the vapors come in contact with the cooler pancake coil. A line connected to the tower at this point back-traps the gas oil to the base of the pressure tower for charging stock to the cracking section of the furnace.

In operating the plant, the charge of cold crude is drawn from storage tanks by a motor-driven Pacific centrifugal pump discharging at 150 pounds through the partial condenser of the split stream of vapors coming from the pressure tower. The partially heated crude continues under the initial pump pressure to the pancake coil in the top of the evaporator where it is further heated by the rising stream of gas oil vapors. From the outlet of this pancake coil, the crude continues in the skimming process to the flash tower with sufficient heat having been imparted to it in the partial condenser and pancake coil that the crude gasoline content of the

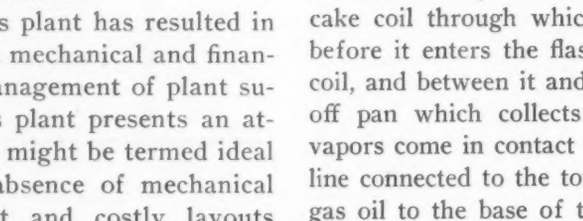


**FIGURE 4**
***Electrically operated water pump in the cooling tower pump house.***

*One of the pump rooms in the Denver plant of Continental Oil Company*

oil, together with the available kerosene fraction is removed without the necessity of passing the charge through a tube section of the furnace. Refluxing in the flash tower is accomplished at two points; one at the top, for the control of the gasoline stream, and the other at the twelfth deck for kerosene fractionation. Gasoline is used as reflux over the top of this tower, governed in quantity by a Foxboro temperature controller, but the rate of kerosene reflux to the twelfth deck is controlled manually by manipulating a gate in the reflux line.

Crude which has been topped of its gasoline and kerosene fractions is pumped from the base of the flash tower with a Byron-Jackson centrifugal motor-driven pump to the evaporator tower. Two points of entry to this unit were provided; one just over the second bubble plate and the other at the base of the evaporator. As the transfer line from the cracking section enters this tower also, the mixture heats the topped crude to such a point that the gas oil fractions are driven from it, without entering the furnace. Cracked bottoms mixed with the topped crude are forced under process pressure through a fuel cooling section and it is now ready to be used as plant fuel or shipped on bunker C specifications.

The vapors driven from the topped crude as well as the gasoline made in cracking rise through the evaporator and pass to the pancake coil at the top. Gas oil is condensed and falls back to the draw-off pan, while the lighter vapors, consisting of pressure gasoline, pass on to the pressure tower to enter above the third bubble plate. Pressure gasoline vapors rise through the tower and split through two lines upon leaving the top, one part being condensed and utilized for reflux over the tower in tower control, while the second stream passes through the two Gray polymerizing towers in series. From the Gray towers, the pressure gasoline vapors are processed through the final fractionating tower and condensed.

Gas oil back-trapped from the draw-off pan in the top of the evaporator enters the pressure bubble tower where in passing from one bubble plate to another falls eventually to the base of this unit where suction is taken by two pumps; one of which circulates the bottoms through the reboiler section of the furnace coils while the other, a seven-stage Pacific motor-driven centrifugal, delivers its charge through the cracking tubes. The discharge end of the transfer line from the cracking tubes terminates in a nozzle placed tangentially in the shell of the evaporator two feet above the bottom. This is done to prevent the formation of coke in the base and to maintain the bottoms in a state of agitation.

All pumps, with the exception of one, are operated by Louis-Allis electric motors. The exception is a small boiler feed pump which furnishes water to the 125 horsepower Stirling type Babcock & Wilcox boiler. Only 50 pounds of pressure is carried on this unit, sufficient pressure for process steam and heating purposes in the buildings of the plant and the employes residences.

# Control and Protection of Oil Refinery Motors

**B. M. MILLS**
***Industrial Engineering Department, General Electric Company***

ELECTRICITY IN REFINERY OPERATION

THE tendency in the design and manufacture of motors and control equipment is to include, insofar as practicable, all features which will result in maximum reliability in service, combined with utmost simplicity in use and in application. In other words, the more the manufacturer "worries", the less the operator will have to worry. It is our purpose to discuss such aspects of design and construction of oil refinery motor control, including both electrical and mechanical protective features, as will be of assistance to the operator in the selection and use of such equipment, and in attaining a better understanding of its capabilities.

Probably 90 per cent or more of all refinery drives consist of the simple constant speed squirrel cage induction motors in one mechanical form or another, such as horizontal or vertical, open or enclosed, explosion-proof, etc. The control usually consists of a full voltage magnetic starter including three-pole contactor, "start-stop" push buttons, protective relays and suitable degree of enclosure to meet the operating conditions. The smaller motors, usually five horsepower or less, may have manual starters, while reduced voltage starters may be required for some of the larger motors to avoid drawing excessive starting currents from the line. The other drives include synchronous motors, adjustable speed brush shifting motors, etc., requiring some control in addition to the switch or contactor and protective relays for opening and closing the line to the motor at the proper time. All of these drives have in common the need for overload protection, short circuit protection, and some form of undervoltage protection, so it is considered advisable to devote some considerable space to a consideration of these features as applied to all motors.

## OVERLOAD AND SHORT CIRCUIT PROTECTION

It is necessary to distinguish between normal overloads, which may range anywhere from rated full load current of the motor to the stalling load of 400 percent or higher, and very heavy evercurrents caused by an actual short circuit. The dividing line is usually set at from six to ten times the full load current of the motor. A motor controller or starter is expected to protect both itself and the motor by opening the power circuit on any sustained overload up to and including a stalled rotor condition before injury is done to the motor, the control equipment or the wiring. Actually, practically all conservatively designed control devices have an interrupting capacity of at least 10 times their applied rating. Fuses, or some form of circuit breaker, are installed in the line ahead of the control and usually ahead of the branch feeder circuit, to protect the motor, the control and the wiring against short circuits, and also to prevent unnecessary shut-downs on other parts of the system by isolating the circuit in which the abnormal condition exists.

The overload device is usually some from of temperature overload relay, in which one or more "heater strips" directly in the power line to the motor or connected in the line through current transformers, act on thermostatic elements to open an auxiliary contact in case of sustained overload, which in turn opens the main switch or contactor by de-energizing the holding coil or magnet. The temperature overload relay is superior to devices of the dash-pot type for this purpose, because it can be made to follow very closely the heating curve of the motor and so not shut down the motor unnecessarily.

Figure 1 shows (a) the heating characteristics of a typical squirrel cage motor; and (b) the tripping

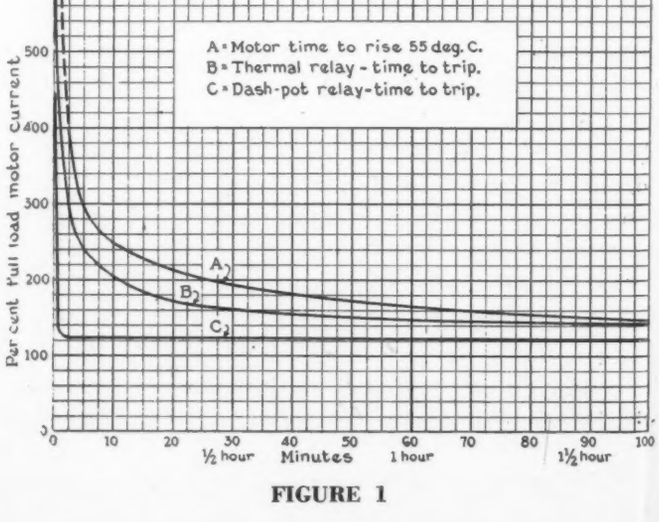



**FIGURE 1**

time of a typical temperature overload relay. These curves demonstrate how, on any normal overload, the motor is kept running until it approaches the maximum safe operating temperature. Curve (c), Figure 1, shows how a dash-pot relay, if set to trip eventually at, say, 125 percent of rated full load motor current, will, on heavier loads, shut down the motor long before it is necessary.

These curves do not show two other important advantages of overload relays of the thermal type. First, if the relay has functioned to shut down the motor due to sustained overload, the relay cannot be reset until its thermostatic element has cooled. This provides a short cooling period for the motor, usually one to three minutes, which does not unnecessarily interfere with production by unduly delaying restarting. Second, the temperature overload relay, when exposed to the same ambient temperature as the motor, has the inherent ability to trip the motor from the line sooner if the ambient temperature is high, and to leave it on the line longer if the ambient temperature is low; so that the ultimate safe operating temperature of the motor is approached but never exceeded before the motor is shut down. Thus, full advantage can be taken of low surrounding temperatures, while full protection is afforded to the motors in case of unusually high temperatures in the vicinity of the motors.

For a standard open type 40°C. rise motor, adequate overload protection is afforded when the temperature overload relay is rated at 115 percent of the rated full load current of the motor. This makes available the usual 15 percent "service factor", which is the ability of the motor to operate continuously with a moderate overload without injurious heating. Enclosed motors, having no "service factor", require a relay rated at full load motor current.

Some temperature overload relays are made adjustable in their setting over a limited range so as to make them more flexible in their application to the exact requirements of a given motor. The tendency, however, particularly with the smaller devices, is to eliminate the adjustable feature, and have smaller increments between successive sizes of heater elements, so that a heater rated very close to 100 per-

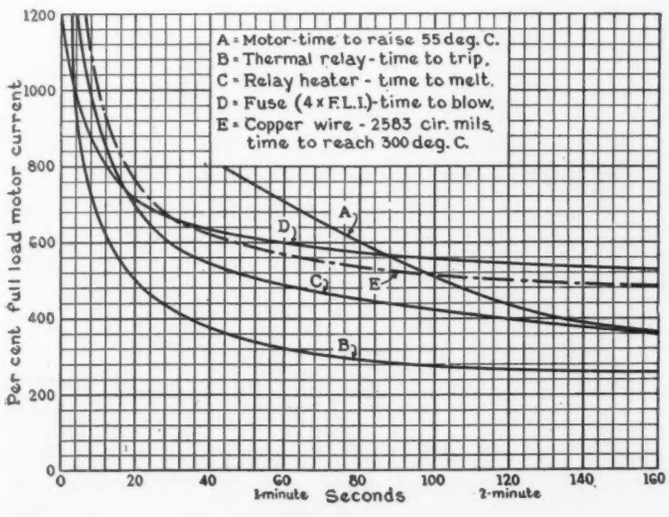
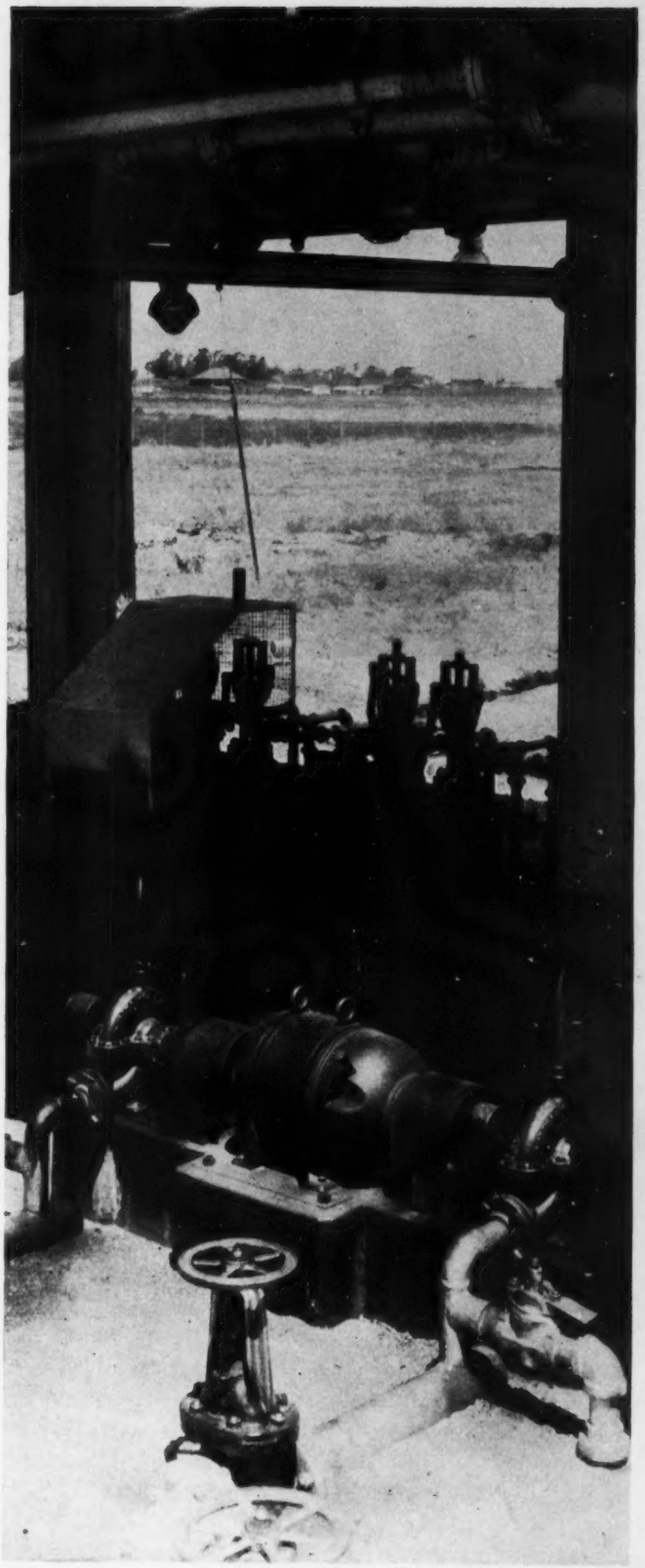
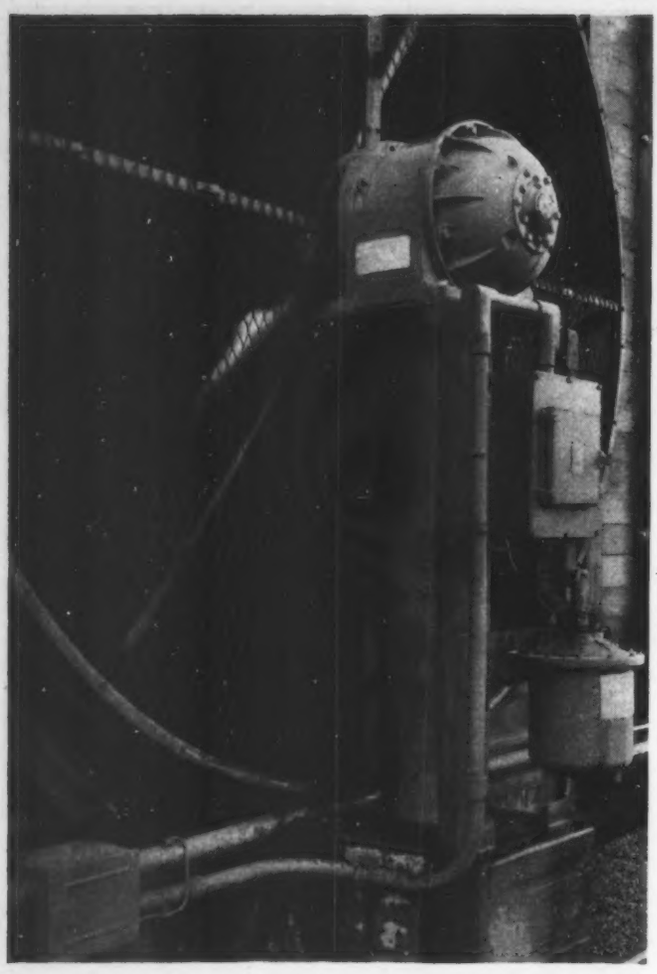



**FIGURE 2**



***Explosion-proof motors driving centrifugal charging pumps (foreground) and acid proportioning pumps (background) in a California refinery.***



***Outdoor installation of totally enclosed, explosion-proof, squirrel cage motor with oil-immersed, explosion-proof magnetic switch. One of four propeller fan drives for cooling tower in an eastern refinery.***

cent or 115 percent of a given motor rating will always be available. Relays of this type, once properly selected, reduce the chances of improper adjustment in service, either inadvertently through lack of experience or deliberately in an attempt to reduce the frequency of tripping. If a motor is found to be tripping off the line very often, the natural tendency is often to "set up" the relay on the assumption that it is not working right, whereas, provided, of course, the relay was selected and adjusted properly in the first place, the chances are that it is only fulfilling its intended function of preventing injurious heating in the motor and any attempt to prevent such action may result in injury to the windings.

Fuses, if used for short circuit protection, should be rated from two to four times the full load motor current. In the conventional three phase AC distribution system, three fuses, one in each line, and two temperature overload relays (or one relay having two thermal elements) afford complete short-circuit and overload protection if selected within their intended capacity. Figure 2, plotted in seconds to show more clearly heating characteristics on very severe overloads, shows how complete protection is afforded, not only to the motor, but to the control and wiring, with such a combination. In this particular example, the control is self-protective on any load up to 10 times normal; on heavier overloads (short circuits), the fuse blows before injury can be done to any part of the system. If fuses are selected larger than four times full load current, complete protection may not be provided; if less than two times full load current, they may blow too soon and too often, causing unnecessary shut-downs. Similar protection will be afforded using in place of fuses either a time limit circuit breaker set at not exceeding four times full load motor current, or an instantaneous type circuit breaker set at not exceeding 10 times full load motor current.

It is good practice to select the fuses or set the circuit breaker for the lowest tripping value which will not interfere with normal operation of the motor, combining minimum cost with maximum protective effect. The choice, within the ranges indicated will, therefore, to a large extent, depend on the characteristics of the motor and of the drive. For instance, if the motor is to be started at full voltage, with a starting current of 600 percent to 800 percent or higher, or if the drive is of the high-inertia type requiring a long acceleration period, it is obvious that the ratio of blowing or tripping current to full load current must approach the maximum. If, on the other hand, the motor is to be started at reduced voltage so that line starting current is reduced, or if the motor is of a type which requires only a relatively low starting current, smaller fuses or a lower setting of the circuit breaker is indicated.

With further reference to Figure 2, it will be seen that on very heavy overloads approaching the short circuit condition, the temperature overload relay takes the motor off the line in considerably shorter time than the motor would take to reach a maximum safe operating temperature. This does not ordinarily mean an unnecessary shutdown, as current overloads on the order of 400 percent and greater usually represent a stalled or almost stalled motor, in which case there is obviously no advantage in allowing the motor to "roast" on the line, and the sooner it is shut down, the better. However, in the case of high speed, high inertia drives, as in the case of a centrifuge or centrifugal hot-oil pump or dual drive, particularly when started on full voltage the acceleration period when starting will be relatively long and during this period the average starting current drawn by the motor will be high, so that often full advantage must be taken of the short-time ability of the motor to sustain heavy loads. To meet this requirement, the relay heater element may be connected to the line through a "saturatd core" current transformer, so that on the heavier loads the current through the

heater element is less than proportional to the line current. By proper design of the current transformer and heater element, the relay tripping curve can be made to follow the motor heating curve very closely during the starting period, as well as on running loads. The relay will then permit starting of the high inertia drive and still provide excellent overload protection on normal running loads after the drive has come up to speed.

## SHORT CIRCUIT PROTECTION

The worth of any short circuit protective device depends not only on the quickness with which it tends to operate in case of a short circuit, but also on its ability to open the circuit on heavy overcurrents, this last factor being known as its interrupting capacity. Tests made on low voltage (110 to 550 volts) industrial systems where power is supplied from three phase transformers ranging from 3000 to 17,000 KVA show maximum average currents on short circuits in the neighborhood of 30,000 amps. The more likely value for an average source is from 10,000 to 20,000 amps. In high voltage (2200 to 6600 volt) AC systems, the current that can flow in a short circuit may be as high as 50,000 to 100,000 amps., but ordinarily in moderate sized plants, the currents to be interrupted are on the order of 5000 to 20,000 amps.

Cartridge type fuses, mounted in enclosed safety type disconnecting switches (available weatherproof, if desired) for low voltage circuits, and oil filled fuse cutouts for high voltage circuits are well adapted for protecting motors within their current capacity and on systems within their interrupting capacity. A fuse is one of the fastest-acting devices for interrupting a short circuit, often opening the circuit within one or two half cycles (1/120 to 1/60 of a second on a 60 cycle system), whereas such devices as contactors or the older designs of oil circuit breakers require several half cycles to start to open.

Some tests were recently made on a 17,000 KVA bank of transformers which were supplied from a large capacity high voltage industrial line. The secondary voltage was 600 volts. A short circuit was made at the terminals of a 75 HP motor, the current having to pass through a set of 300 amp. fuses, a 150 amp. contactor, and a set of 80 amp. temperature overload relay heaters. The current reached a root-mean-square value of 26,000 amps. Several short circuits were made on this same starter, the fuses acted entirely satisfactorily, and no material damage was done to the starter. Short circuits have occurred a number of times on this same system through 60 amp. fuses without the connected load being damaged, but no records were made of the currents. Based on actual tests it is safe, therefore, to assume that a fuse is a safe device with which to protect against short circuits on low voltage circuits.

Low voltage fuses are available up to and including 600 amps., and so may be used for short circuit protection for motor circuits having a full load rating up to 150 amps. (4:1 ratio between motor current and fuse rating), or 300 amps. (with 2:1 ratio). Fuses are particularly well suited to circuits of 50 amps. and less. Outside of these ranges, circuit breakers should be used, set to trip as indicated above, and having an interrupting capacity adequate for the circuit. There have recently been put on the market, in ratings and interrupting capacities paralleling those of fuses, small compression-chamber type low voltage air-circuit breakers which may come to be preferable to fused disconnect switches because of the elimination of the inconvenience and cost of fuse replacements.

**TABLE I**
**Ratings of Oil Fuse Cutouts**

| Voltage | Horsepower Range | Contactor Size | Fuse Interrupting Capacity |
|---|---|---|---|
| 2200 | 20-250 | 75 amp. | 5000 amp. |
| 2200 | 20-250 | 150 amp. and larger | 10,000 amp. |
| 3000 | 20-125 | 150 amp. and larger | 5000 amp. |
| 3300 | 20-150 | 150 amp. and larger | 5000 amp. |
| 4000 | 20-200 | 150 amp. and larger | 5000 apm. |
| 4600 | 20-200 | 150 amp. and larger | 5000 amp. |
| 5000 | 20-250 | 150 amp. and larger | 5000 amp. |
| 6600 | 20-250 | 150 amp. and larger | 3750 amp. |

Oil fuse cutouts for high voltage circuits have in-

***Steel Panel Switchboard Mounting Switchgear Equipment in a California Refinery.***

terrupting abilities as listed in Table I. These ratings are quite conservative because they are made with the expectation that a man may be inserting the fuse while short circuit still exists.

For short circuit protection of larger motors or for all motors where larger interrupting capacity is required on high voltage circuits, the oil circuit breaker should be used. One unusual condition which is sometimes encountered in a refinery system is that where the generating equipment is located right at the refinery and there are no step-up or step-down transformers between the generators and the 2200 volt distribution system. In this case, exceptionally high interrupting capacity may be required from the breakers unless current limiting reactors are used in each branch circuit.

Cartridge type fuses when used in connection with motors in hazardous gas locations, should always be installed in the feeder circuit outside the danger area. There is yet much to be learned as to the possibilities of adequate protection of fuses in hazardous locations. Experience and tests so far indicate that fuses installed in an explosion-proof housing may, when blown, develop excessive and dangerous pressures, while standard cartridge type fuses, oil immersed, are considerably changed and uncertain in their blowing characteristics and may, when they blow, cause dangerously violent disturbance of the oil. Where it is not feasible to locate a fused switch outside the danger area, it is recommended that some form of adequately protected circuit breaker be substituted.

## UNDERVOLTAGE PROTECTION AND RELEASE

A control device is said to provide undervoltage protection, when, in the event of power failure or reduction of line voltage to around 50 percent of normal, it functions to shut down the motor so that, upon return of power or full voltage, it will not start up again until started by the operator. Undervoltage release is provided when the control is so arranged as to re-start the motor automatically, without the attention of the operator, upon the return of power. The choice depends on the drive, on the effect on process and on safety considerations. For example, in the case of a circulating water pump, it might be desirable to have the motor start up automatically as soon as possible after a power failure, so that undervoltage release would be preferable. On the other hand, it would not be feasible to start up in this manner, a compressor which has to be manually unloaded during the starting period. The unexpected re-starting of a conveyor drive or any belt drive, might be extremely dangerous to the attendants. In these latter examples undervoltage protection is obviously preferable.

Because of the importance of uninterrupted production in a refinery, every precaution is taken to prevent interruption of the power supply. Usually, two or more power sources are available with duplication of transmission equipment, transformers, etc. where necessary to assure utmost reliability. Proper relaying of these circuits makes possible quick automatic transfer in case of trouble in any one link in the chain, so that loss of power in a well designed refinery system will seldom if ever occur. Momentary dips in voltage, caused by sudden large changes in load or in transferring from one power source to another may, however, be of sufficient duration and magnitude, to shut down some essential drive. In a check-up of one large power system, it was found that more than 70 percent of the power interruptions were of less than two seconds duration.

The time delay undervoltage device is most useful in preventing shut-downs during such momentary interruptions of power. This device, in the forms applied to oil circuit breakers and latched-in contactors, prevents tripping of the switch on low voltage for a period of 1½ to four seconds, or more. Magnetic contactors, which are held closed by the energization of solenoid magnets, cannot be prevented from opening on momentary interruption of power, but the time delay push button will, for a similar period, maintain a contact which will reclose the line contactor if power supply in resumed within that period. The time interval in which it is practicable to reenergize the motor circuit without first bringing the motor to a standstill and re-starting depends on the drive, but an interruption of two seconds or less will not usually cause much slow-down, and the proper time delay undervoltage device, if used, will greatly reduce the possibility of an unnecessary shut-down.

## MOTORS AND CONTROL FOR REFINERY SERVICE

The above comments on overload protection, short circuit protection, etc., are applicable to the electrical equipment in almost any industry. In addition to these basic electrical protective features, oil refinery equipment very often requires mechanical and surface protection of a specialized nature to meet adequately and reliably severe operating conditions in unfavorable surroundings, particularly hazardous gas locations and corrosive fumes, either separately or together. During the last five years, electrical manufacturers have made available motors and control equipment, especially well suited to refinery conditions. These have been well received and widely used by the industry.

Perhaps the outstanding development has been the totally enclosed, fan-cooled motor, which is now so commonly used in refineries as to require little description here. In this motor, an inner housing, with small clearances and adequate seals at the shaft and with cartridge type ball bearings, provides a complete enclosure for the rotor and stator.

An outer housing forms an air passage through

which cooling air is forced by a fan keyed to the shaft between the inner and the outer end shields. The design provides positive and direct cooling, together with strong and rigid construction and greater output per pound of material than is possible with ordinary methods of total enclosure. The fan-cooled construction also permits considerably larger ratings for enclosed motors than are otherwise practicable. Explosion-proof motors are similar except for the heavier construction, wide metal to metal joints and other required special details in accordance with the specifications of the Underwriters' Laboratories for Class I Group D hazardous locations.

This type of motor in both the explosion-proof and the non-explosion-proof forms is rapidly replacing other types in such locations as the centrifuge plant, fullers earth plant, acid recovery plant and in driving reflux pumps, distillate pumps, etc. In addition, it is particularly well suited to meet the trend toward outdoor installations. Not only is the housing expense reduced or eliminated, but, in the case of hazardous gas conditions, there is much less chance for concentration of the gas in explosive or inflammable mixtures.

Where motors are installed in hazardous gas locations, or in the presence of corrosive fumes, or outdoors, the starters, if placed near the motors, must have adequate protective features. Corrosion resisting control is usually oil-immersed. Explosion-proof control for Class I, Group D hazardous gas conditions, including gasoline, natural gas, distillates, etc., is either oil-immersed in accordance with the specifications of the Underwriters' Laboratory or it is housed in cast iron or boiler plate cases having sufficient strength and wide metal to metal flanges, to withstand the pressure of an internal explosion without emitting sparks, flames, or gases at a temperature which would ignite flammable mixtures in the surrounding atmosphere. This construction is in accordance with the Underwriters' Laboratory specifications covering air-break control for Class I, Group D hazardous locations. Control for outdoor use is housed in a weather-proof enclosure and may be oil-immersed. It should be noted that a control oil immersed for hazardous gas conditions differs considerably from one which is oil immersed merely for protection against corrosion. In the former case, the Underwriters' Laboratory specifications include the requirement that all contact making and breaking parts, as well as all connections, be at least six inches under the oil level. Hence, an oil immersed, explosion-proof device is ordinarily corrosion resisting, but an oil-immersed, corrosion-resisting device is not necessarily explosion proof.

A wide range of types and sizes of control equipment is available to meet almost any refinery conditions. One popular type of magnetic starter, with separate push button stations to match, is available in an enclosure of explosion-proof, weather-proof construction, and in addition is oil-immersed for protection against corrosion. Another type, oil immersed, suitable for use in hazardous gas locations, corrosion resisting and weather-proof, has a built-in disconnecting switch.

Still another type of magnetic starter, for use where hazardous gas conditions are not encountered, is oil-immersed, corrosion resisting and weather-proof. Small manually operated starters with tem-

***Control and Exciter sets for synchronous motors driving compressors in a Texas natural gas gathering plant. Motors Class I, Group D construction coupled to generators of similar construction. Control has all contacts oil-immersed and relays are in an enclosure of Class I, Group D construction.***

perature overload protection are available in the air break explosion-proof construction for motors up to 7½ horsepower at 440 volts.

Where it is not essential to have the control in the same location as the motor, the control for several motors is often grouped in one place, free from corrosive fumes or hazardous gases, and suitably protected from the weather. In this case, the control can be of the standard type; only the push button station, near the motor, need have special protective features.

As it is not ordinarily practicable to apply the totally enclosed, fan-cooled construction, to motors much larger than 200 to 250 horsepower, centrifugal hot-oil pumps, requiring 250 to 1500 horsepower at 3600 r.p.m. are often driven by enclosed, self-ventilated motors. A base-ventilated motor of this type, totally enclosed to the floor level and arranged for connection to incoming and outgoing air ducts under the floor, has been installed on many of these drives. When air must be carried a considerable distance to assure freedom from hazardous gases, a separate motor driven blower is installed in the duct system, which may supply air to several motors.

Reciprocating hot-oil pumps are often driven by adjustable-speed motors of the low voltage AC, brush-shifting, commutator type, installed in a motor room separated from the pump by a fire wall. This type of motor is usually equipped with a pilot-motor-driven brush shifting mechanism for remote control.

The control for the larger squirrel cage motors is often of the standard, non-protected type, grouped in a control room remote from the unfavorable location. The high voltage controllers are practically always oil-immersed for compactness. The low voltage controllers may be oil-immersed for protection against corrosion or hazardous gases.

### SYNCHRONOUS MOTORS AND CONTROL

Motor-driven reciprocating gas compressors requiring more than 50 or 100 horsepower are driven by low-speed synchronous motors mounted on the compressor crankshaft. Some operators consider that only the collector rings and brush rigging need special protection. An enclosure covering the rings is supplied with air from a remote point by means of a small motor-driven blower so interlocked with the main control, that the synchronous motor cannot be started until the blower has been running for 30 seconds or more, to clear out any gases which may have accumulated in the collector ring enclosure during a shut-down period.

More complete protection is afforded when the entire motor is enclosed, and ventilated. One installation of three totally enclosed, fan-cooled, low-speed synchronous motors, has been made in a natural gas gathering plant. The size and construction of the motor prohibited explosion-proof construction, but the interior of each motor is kept filled with an inert gas (flue gas or carbon dioxide) under a pressure of a few inches water gauge so that leakage will be outward and no explosive mixture can accumulate inside. Cooling air, supplied by a fan keyed to the shaft, is directed over the inner enclosure as in the ordinary totally enclosed fan-cooled induction motors.

A few installations have also been made of totally enclosed, fan-cooled synchronous motors around 100 horsepower, 1000 or 1200 r.p.m., running distillate pumps, or belted to small gas compressors. These motors are similar in construction and appearance to the induction type, and have the collector rings in a separate enclosure outside the bearing housing. They may be installed outdoors.

Synchronous motor control may be of the magnetic or the semi-magnetic type, and in refineries is usually arranged for starting the motor on full voltage. In the semi-magnetic type, the motor is started by closing the line switch by hand. After the motor has come up to speed on the squirrel cage winding, field excitation is applied automatically and the motor pulls into step without further attention. In the full magnetic starter, it is necessary only to push the "start" button to throw the motor on the line, bring it up to speed, apply field excitation at the proper time, and pull into synchronism.

A synchrouous motor, in addition to overload and undervoltage protection, requires special protection of the squirrel cage starting winding in case for any reason, the motor comes up to speed too slowly, or fails to pull into step when field excitation is applied, or in case field excitation is lost. Any of these conditions may cause the motor to run as an induction motor, subjecting the squirrel cage winding to loads for which it was not intended with the possibility of causing injurious heating in this winding unless the motor is shut down. To protect against these conditions, a "temperature squirrel cage protective relay" is used in addition to the temperature overload relays in the line. At all times when the motor is running as an induction motor, below synchronous speed, the heater element of the "temperature squirrel cage protective relay" is connected across the motor field in series with the field discharge resistor and in parallel with a small reactor. When the motor is running on the squirrel cage winding, and below synchronous speed, alternating current is induced in the field circuit at a frequency corresponding to the slip, or reduction in speed below synchronous speed. The frequency is a measure of the heating in the squirrel cage winding; at and near stand-still, both the frequency and the heating are the greatest. As the frequency increases with decreasing speed, more and more of the induced current in the relay circuit is diverted from the reactor and sent through the heater element which functions to shut down the motor before injurious heating in the squirrel cage winding occurs.

A synchronous motor also requires a means of

removing field excitation, if the motor falls out of step, to avoid excessive line disturbances due to fluctuating current. This may be accomplished by the use of the "power factor field removal relay." When the motor falls out of step and runs on the squirrel cage winding as an induction motor, there is a marked change in power factor. As its name implies, the "power factor field removal relay" is responsive to this change and functions to disconnect the field from the exciter or exciter bus, at the same time connecting the field discharge resistor and "temperature squirrel cage protective relay" across the field.

Synchronous motor control, if required to operate in hazardous gas locations, usually has all the main contacts oil immersed; auxiliary relays, and field control, may be oil immersed or placed in an enclosure of Class I. Group D construction. However, the greater difficulty and expense of protecting so much switching and control equipment usually makes standard control in a remote location preferable.

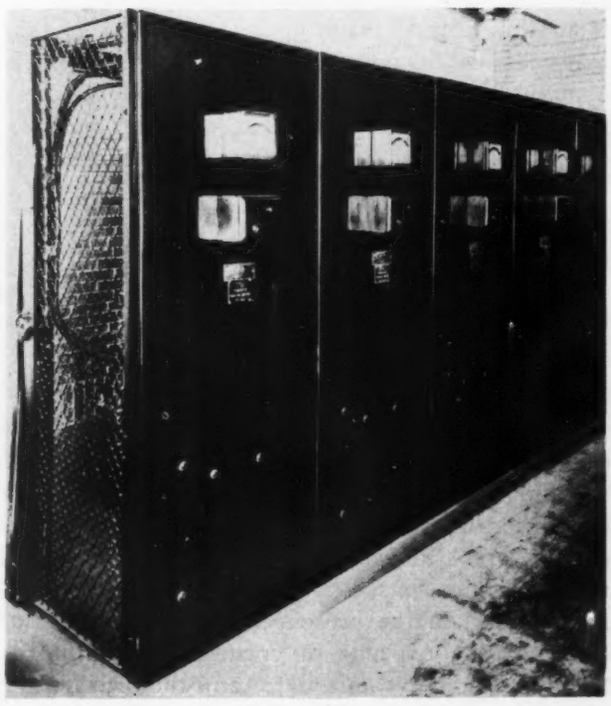
### SPLASH-PROOF MOTORS AND CONTROL

Splash-proof motors, designed to prevent the entrance of any liquid or solid particles falling on or approaching the motor, in a straight line at an angle of not more than 100 degrees from the vertical, may be used in outdoor locations in refineries where the climatic conditions are such that ice and snow will not interfere with the ventilation of the motor. This type of motor is not recommended for use where exposed to hazardous gases, corrosive fumes, or, during shut-down periods, to excessively high humidity, for the reason that ventilating air in this type of motor is drawn through the windings just as in an open motor, and the injurious elements are not excluded as they are in the totally enclosed fan-cooled motors which are more universally applicable to refinery drive. Control for splash-proof motors if located near the motor, may be of the weather-proof type.

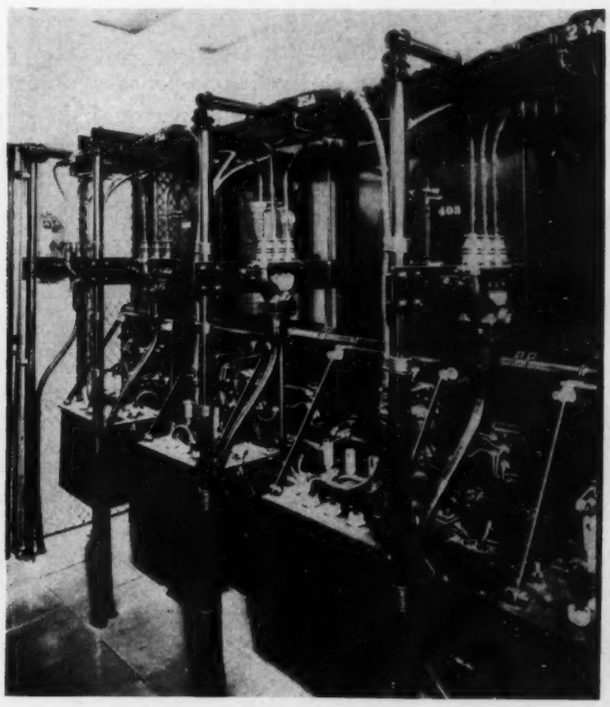
### WIRING, CONDUIT, ETC.

Feeder circuits are usually run in rigid conduit for adequate mechanical and and electrical protection and reliability. Feeders for outdoor installations are preferably run underground, using armored "Parkway" cable. Conduit running to motors and control in hazardous gas locations should, for safety, be equipped with explosion-proof fittings. Where the leads enter or leave an explosion-proof device, such as a starter, they should be sealed in compound inside the conduit, preferably using a special fitting available for the purpose which facilitates the filling and tends to insure a complete seal. Lighting circuits are usually equipped with vapor-proof fittings and switches, and with adequately protected fixtures to guard against the hazard of accidentally broken lamp bulbs and consequent exposed arcing.

All of these precautions tend not only to insure the reliability so essential to refinery equipment, but the safety which is more and more becoming stressed as of basic importance in the selection and use of equipment by this industry.



*Front View*



*Back View*

***Grouped magnetic control with lacquered steel panels for control of totally enclosed fan-cooled, vertical induction motors, driving circulating pumps in a California refinery.***

ELECTRICITY IN REFINERY OPERATION

# Motors Should Fit Refinery Conditions

D. E. RENSHAW
*Petroleum Engineer, Westinghouse Electric & Manufacturing Company*

IN the selection of refinery motors, the purchaser should consider, not only the special conditions prevalent in all refineries, but also his local conditions which may dictate the choice of one or another type of motor construction. The problem of motor application may be divided into two parts, the first of which involves determination of ratings and electrical characteristics. The second part involves consideration of local conditions to obtain the maximum in reliability and safety and the minimum overall cost.

## RATING AND CHARACTERISTICS OF MOTOR

Probably more than 90 percent of refinery motors are used in pumping liquids or gases of known characteristics at pressures and in quantities which are predetermined. The determination of ratings from these data is accomplished by well known, direct methods, without long and laborious duty cycle calculations.

Although it is necessary to regulate the rates of flow through some of the refinery process pumps, speed regulation is seldom used to accomplish this. Equivalent results can be obtained by throttling a centrifugal pump or by-passing a plunger pump at little or no sacrifice in efficiency and without the added expense and complication of a variable speed drive. Constant speed motors have such distinct advantages that there are few, if any, places where another type is superior.

**FIGURE 1**
***Solid cast frame motors are durable under mechanical loads.***

As between the two types of alternating current constant speed motors, synchronous and squirrel cage, certain generalities can be stated.

A squirrel cage motor is the least expensive and most simple and durable type of motor built. Even in open type construction, it is relatively safe in explosive atmospheres, since only a bearing failure, resulting in a mechanically produced spark, or an insulation failure, resulting in an electric spark, can cause an explosion. It has no exposed slip rings, commutator or brush rigging to be attached by corrosive vapors, or to produce an explosion hazard. It can be built economically for the maximum speed (two pole design) as well as the lower speeds.

Therefore, squirrel cage motors should be used:

1. For high speed drives (two pole motors).
2. For small and medium size motors, up to 100 horsepower, regardless of speed or location.
3. In all areas where corrosive or explosive vapors are present, regardless of size or speed.

Synchronous motors in sizes about 100 horsepower offer the least expensive means of power factor correction. Equivalent results can be obtained by static condensers more cheaply than by smaller synchronous motors. But, as previously suggested, they are not economical in the two pole type, and they should not be used in the presence of harmful vapors, because of the expense of enclosing the motor slip rings, the exciter commutator and the brush rigging.

For pump drives which seldom require high starting torque, general purpose motors having starting torque equal to 1.25 to 1.5 times full load torque, are generally adequate. For coke or clay conveyors

or pulverizers or for clay burner drives, class 2 motors having starting torque equal to 2.0 times full load torque, may be required.

### PROTECTION FROM CORROSIVE GASES

While the electrical features of refinery motors thus are easily chosen, mechanical features, including insulation, frame materials and construction, bearings, their supports and protection, require close study to insure the reliability and overall economy so essential in long extended, continuous process work.

In refineries the most common cause of insulation failure is chemical penetration into the insulating materials. From the nature of the materials and the method of their application, the wrappings on the individual conductors and coils cannot prevent this penetration. However, thorough protection can be obtained by dipping the coils in penetrating varnish both before and after assembly in the machine, following each dip by a baking, and repeating the process until all voids are filled and the surfaces adequately covered. The varnish must, of course, be highly impervious to acid attack and must retain sufficient plasticity to permit expansion under increasing temperature without cracking. With the windings thus sealed, the small amount of acid condensation which may occur will be harmless.

**FIGURE 2**
***Weatherproof motors can be used to save building costs.***

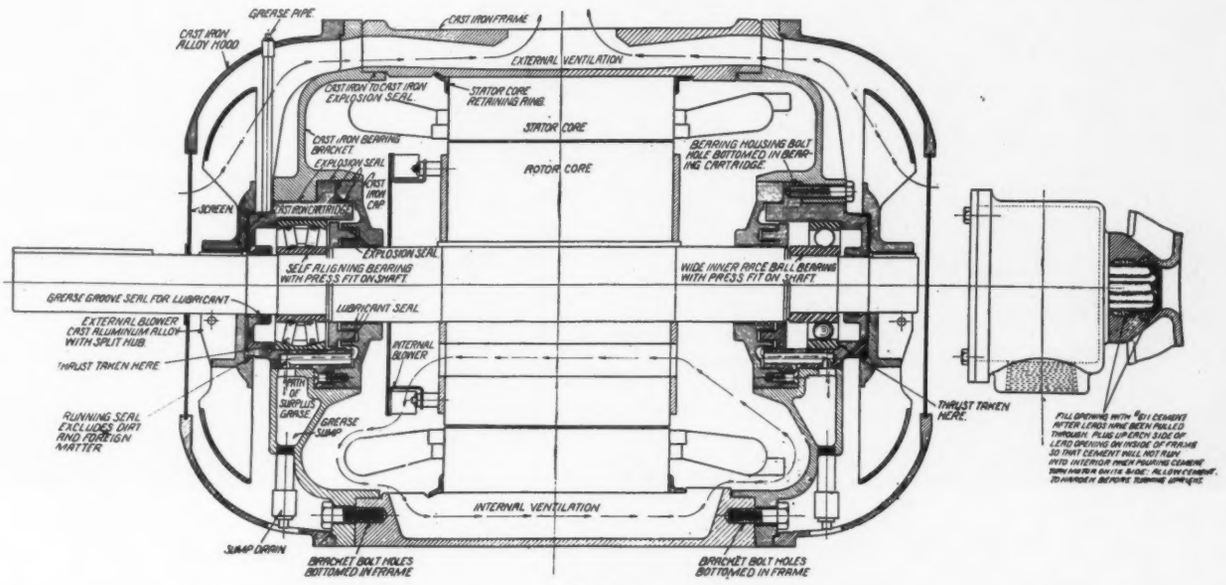

GREASE PIPE
CAST IRON ALLOY HOOD
CAST IRON FRAME
EXTERNAL VENTILATION
CAST IRON TO CAST IRON EXPLOSION SEAL
STATOR CORE RETAINING RING
STATOR CORE
CAST IRON BEARING BRACKET
EXPLOSION SEAL
ROTOR CORE
BEARING HOUSING BOLT HOLE BOTTOMED IN BEARING CARTRIDGE
CAST IRON CAP
SCREEN
CAST IRON CARTRIDGE
EXPLOSION SEAL
SELF ALIGNING BEARING WITH PRESS FIT ON SHAFT
WIDE INNER RACE BALL BEARING WITH PRESS FIT ON SHAFT
GREASE GROOVE SEAL FOR LUBRICANT
LUBRICANT SEAL
EXTERNAL BLOWER CAST ALUMINUM ALLOY WITH SPLIT HUB
INTERNAL BLOWER
THRUST TAKEN HERE
PATH OF SURPLUS GREASE
GREASE SUMP
RUNNING SEAL EXCLUDES DIRT AND FOREIGN MATTER
THRUST TAKEN HERE
INTERNAL VENTILATION
SUMP DRAIN
BRACKET BOLT HOLES BOTTOMED IN FRAME
BRACKET BOLT HOLES BOTTOMED IN FRAME

**FIGURE 3**
***Cross section of a fan-cooled explosion-resisting motor.***

It is a fortunate circumstance that cast iron is a material which is at once highly acid resistant, cheaper than "stainless" materials and gives the ruggedness and rigidity necessary for durable construction.

### OUTDOOR EQUIPMENT

In regions where atmospheric and weather conditions are favorable, the use of outdoor motor driven pumps may result in savings. The first cost and maintenance expense of outdoor equipment is but little more than corresponding costs for indoor equipment. Pumps generally may be placed at the most convenient point, eliminating piping necessary when a number of small machines are grouped in a single building. Building costs are saved. In some cases,

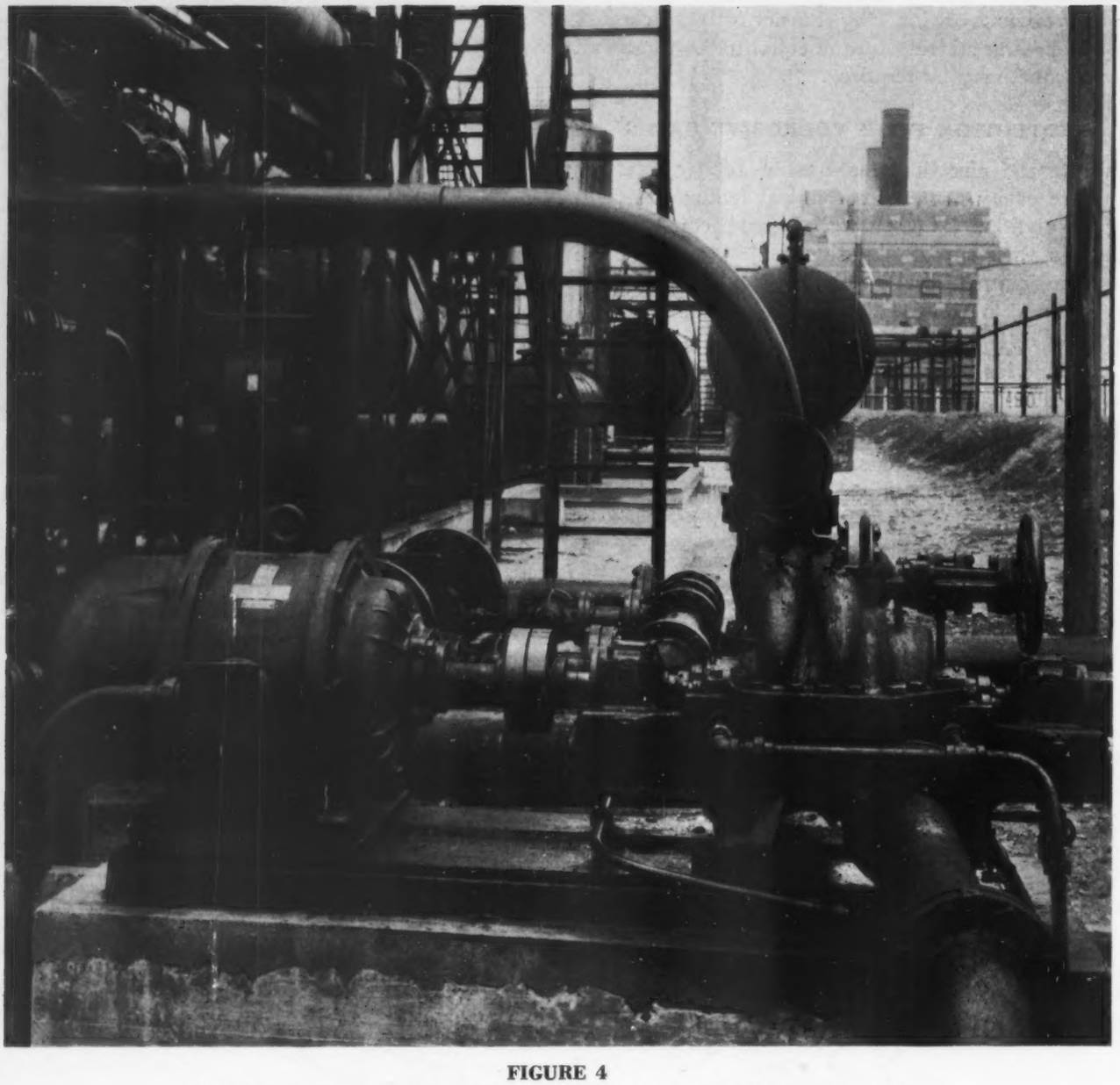


**FIGURE 4**
***A 30-horsepower explosion resisting weatherproof motor driving a centrifugal gasoline pump in a Texas refinery***

outdoor equipment is definitely out of the hazardous zone, regardless of the material being pumped, because there is small possibility of explosive gases remaining in concentration in the vicinity of the motor.

This question of indoor vs. outdoor equipment will be of small importance on revamping jobs where buildings are available in suitable locations, since these buildings will naturally be used.

In outdoor non-hazardous locations, weather-proof equipment of the type illustrated by Figure 2 may be used with assurance that moisture will not enter the motor to damage the windings.

## HAZARDOUS LOCATIONS

In hazardous locations, indoors or outdoors, explosion resisting construction will be required to minimize the dangers of fires and explosions. A type of construction which has been developed for the larger sizes is illustrated by Figures 3 and 4. As the motor dimensions and ratings increase, it becomes increasingly difficult to remove the heat from the cores and windings. To obtain rapid transfer of heat from inside the motor to the cooling air, the motor frame is cast with parallel ducts for internal and external air, giving a heat transfer system similar to that obtained in heat exchangers.

Figure 3 also illustrates a modern type of antifriction bearing housing. The housing is of the cartridge type and is not disturbed by the removal of the bearing bracket. The bearings are retained in place on the shaft by a press fit, without lock nuts, pins or screws. When the bearing is removed from the shaft, pressure is exerted directly on the inner race, not on the outer race and through the balls or rollers. The lubricant and explosion seal at the inner end

of the bearing is of the labyrinth type. A bearing sump is to be provided to take the excess grease when the bearing is filled under pressure. Each of these features is desirable.

### LARGE INDUCTION MOTORS

Large motors driving hot oil pumps are generally of the high speed, two pole squirrel cage type. The importance of these machines to the continuity of the process, the necessity for periodic pump repairs and the cost of making these motors either weatherproof or explosion resisting usually dictates that these machines be placed indoors with a firewall separating the motor and pump rooms. The bearings for these motors will be of the sleeve type, adequately sealed to prevent the entrance of dirt and the loss of lubricant. For ratings of 600 horsepower and over, forced feed lubrication should be used, while for the smaller sizes, ring type oil feed will be satisfactory.

### SYNCHRONOUS MOTORS

Since the many motors which drive pumps to carry the crude and its derivatives through the refining processes are of the induction type, some power factor correction is usually desirable to keep down distribution losses and to make possible the use of minimum size distribution and generating equipment. Compressors and circulating water pumps operating at 1800 r.p.m. or less, are ideal applications for synchronous motors, since the required speeds and torques are conducive to efficient synchronous motor design, and since these units can usually be placed outside the zones of corrosive and explosive gases. By the use of 80 percent power factor motors, leading "power" equal to 75 percent of the rating of the motor is made available.

To reduce starting currents in large synchronous motors thereby minimizing disturbances to the generating and distribution system, several types of motor construction or starting schemes are available. Standard general purpose motors may draw six times full load current when started at full line voltage, and may produce two times full load torque at starting. Probably the most simple method of obtaining low power inrush at starting is by the use of specially designed damper windings in the field pole faces. By this method, starting and pull-in torques of 60 percent and 100 percent, respectively, of full load torque may be obtained at a starting inrush of four times full load KVA. or less. This performance is usually adequate for refinery compressor and water pump drives and has the merit of requiring only a simple line start type controller.

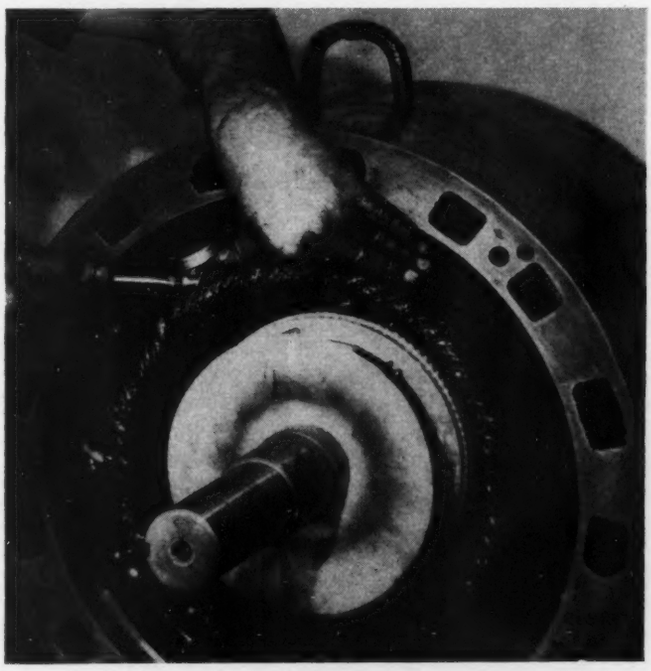


**FIGURE 5**
***A small thermostat mounted directly on the windings of the fan-cooled motor gives protection against overheating.***

### SUMMARY

Practically all the motors used in refineries drive pumps or compressors.

Motor ratings and speeds are easily determined from the volumes and pressures specified by the refinery designer.

Constant speed motors can usually be used without sacrifice of overall economy.

Squirrel cage motors are almost universally applicable.

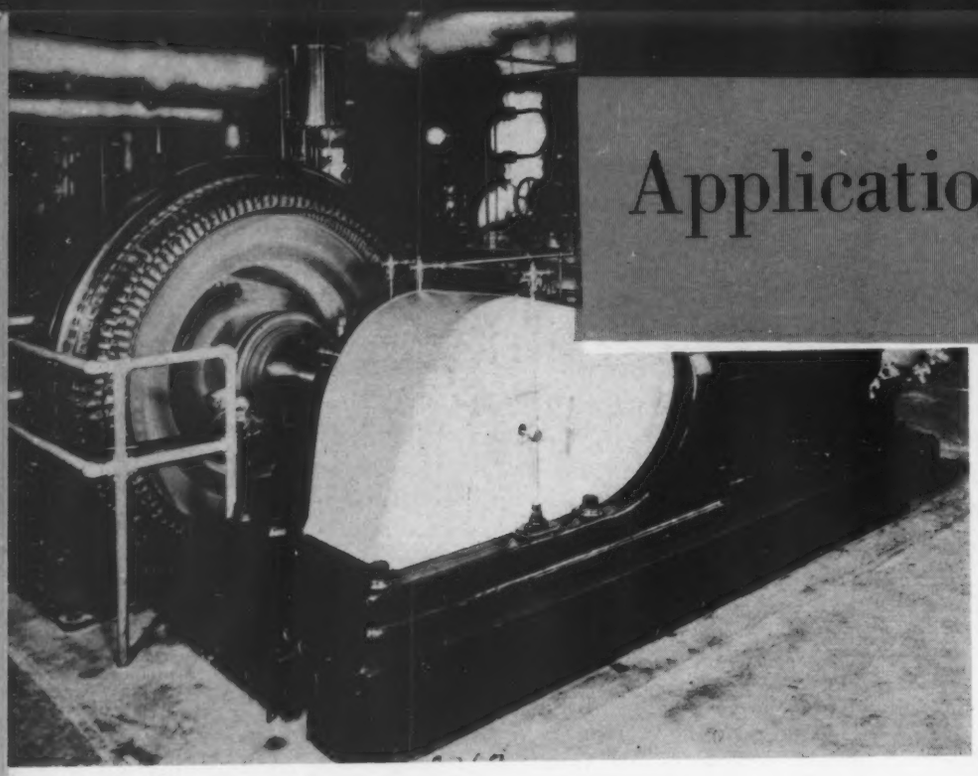
Synchronous motors should be used for large compressors and pumps at 1800 r.p.m. and below in non-hazardous locations if power factor correction is desired.

The presence of acids and acid bearing vapors makes the selection of materials and insulation of great importance.

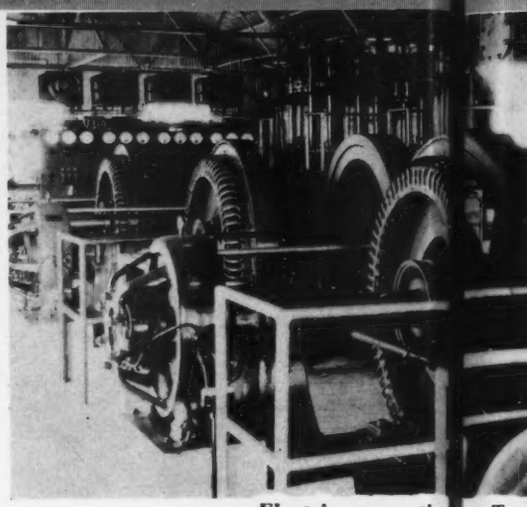
In some localities, motor driven equipment may be placed outdoors with consequent reduction in expense.

In areas where explosive materials may be present, small and medium size motors should be of the explosion resisting type. Large motors shoud be separated from the hazardous area by a fire wall.

# Application of Electrici To

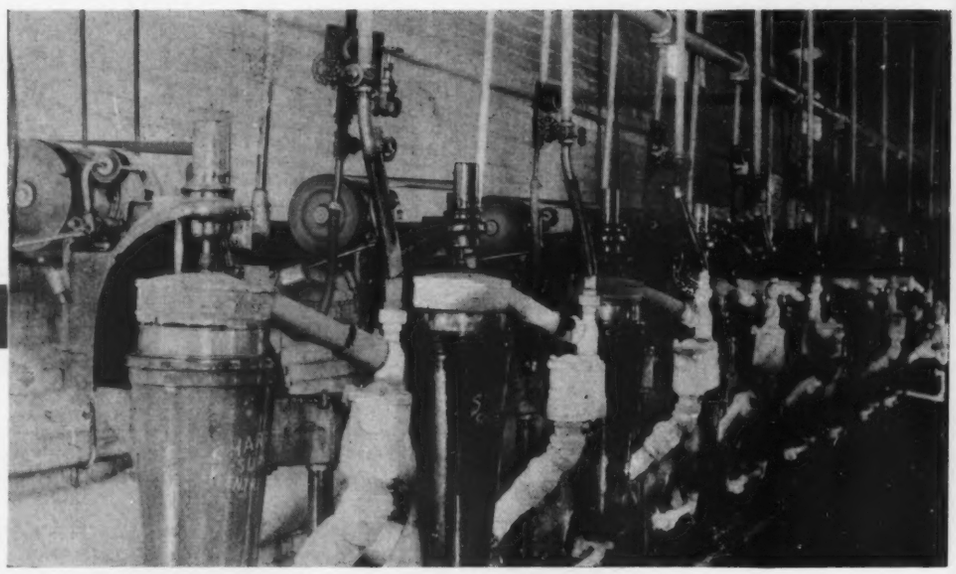


*Synchronous motor-driven ammonia compressors.*



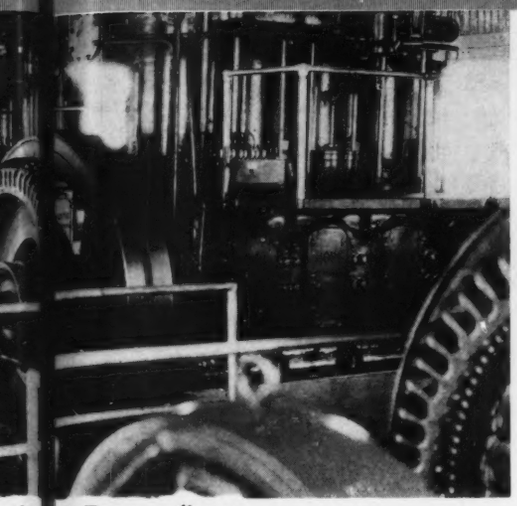
*Electric generating* *t Tex*

*Right: Battery of motor-driven centrifuges in de-waxing plant.*

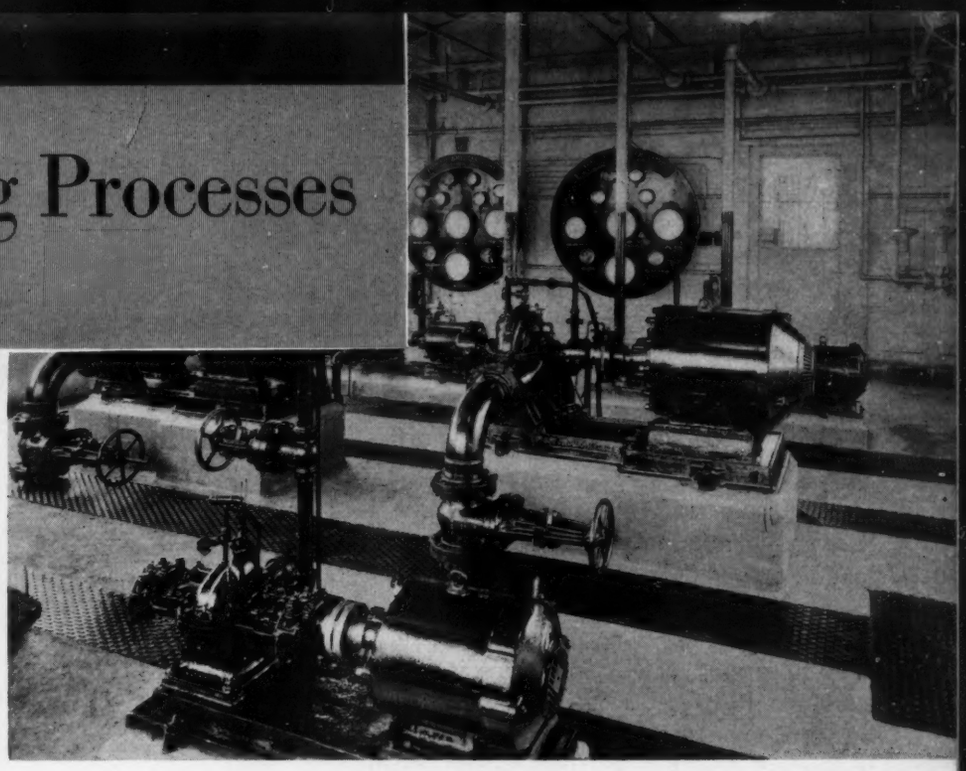


*Below: Acid-oil mixing equipment in cold treating system.*

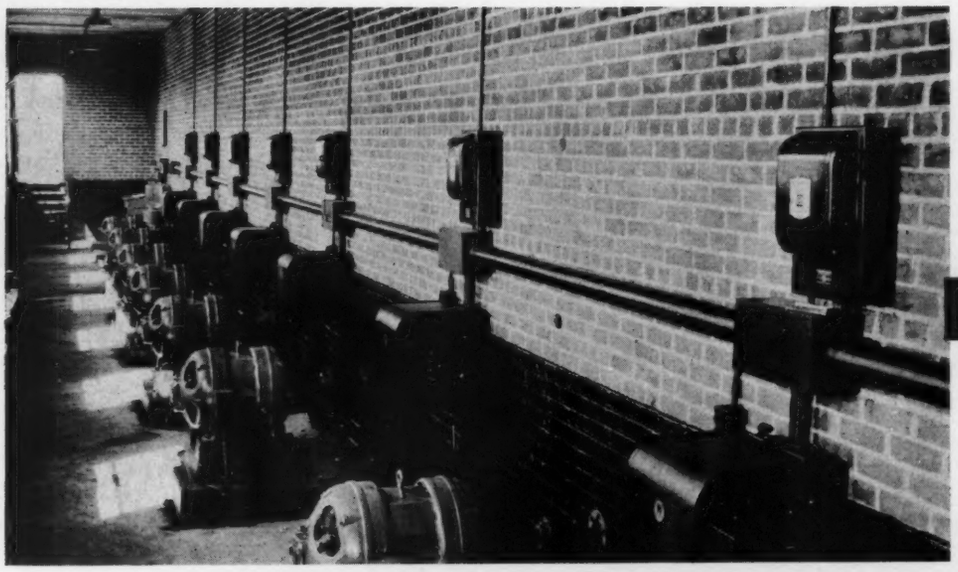
# ci To Oil Refining Processes



*ating est Texas refinery.*

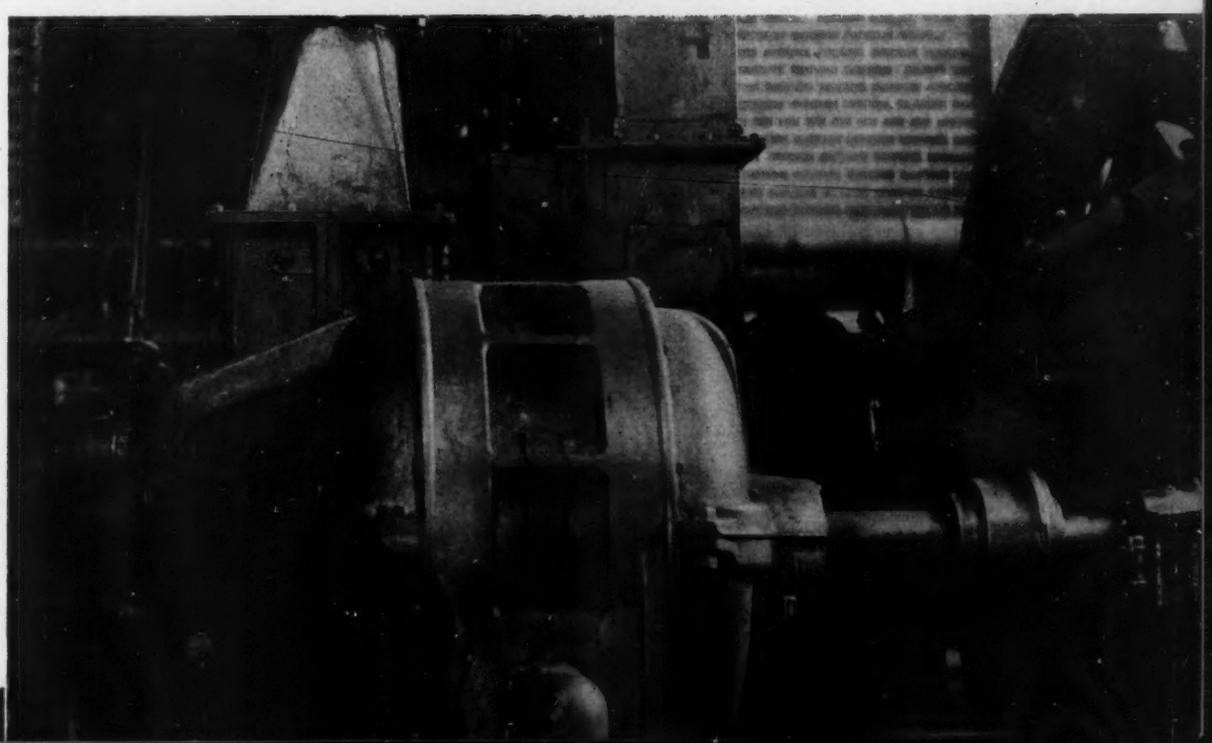


*Explosion proof motors in a stabilizing plant.*



*Left: Motors operating centrifugal transfer pumps through fire wall.*

*Below: Motor-driven ball mill and blower in a refinery furnace room.*



# Electricity *in* Instrumentation

ELECTRICITY IN REFINERY OPERATION

**JOEL H. HIRSCH**
***Member of Staff of Luis De Florez, Consulting Engineers, New York***

DEVELOPMENT of continuous processing in petroleum refining has established the need for precise coordination of operating conditions and the elimination of undue variation in such fundamental factors as flow rates, temperatures and pressures. It is evident that the mere matching of quantities, such as was possible in former "batch" operations, is no longer sufficient and that the success of the continuous process is dependent upon the precise matching of rates. This requirement has led to fundamental changes in plant design, such as centralization of control, and has necessitated the development of precision instruments for measurement and control, in operation of many of which electricity has played an important part.

Many instruments embodying electrical circuits either directly for measurement or as an auxiliary in transmitting, recording or evaluating processing data have become so customary to general refinery operation that the importance of electricity in instrumentation is not always fully appreciated. For this reason, in a review on electricity and its application to the refining industry, it seems apropos briefly to review, from the standpoint of operating mechanisms and chief uses, the principal instruments embodying electrical circuits now in general use, and to consider in the same light some of the more recent instruments of this type which have not yet been generally adopted.

Instruments may be roughly divided into two classes, first, those which measure and report data on either indicating or recording mechanisms, but require human intelligence for the recognition, analysis and adjustment of deviations from the desired operating conditions, and second, automatic control instruments which recognize, analyze and adjust deviations without manual intercession.

Thermo-electric circuits have attained widespread application in refining processes for temperature measurement. The thermo-couple has been applied to substantially all temperature measurements above 500° F. and is commonly used for such measurements above 100° F.

The oldest type of indicating or recording mechanism used in conjunction with the thermo-couple is the millivolt meter, which simply measures the difference in potential between the hot and cold junctions. Millivolt instruments have a serious drawback in that the reading on the millivolt meter is dependent on the resistance of the lead wires to the instrument as well as that of the thermo-couple. While these instruments may be calibrated with a given length of lead wire, the resistance of the external circuit may be altered by atmospheric temperature changes, loose connections, and corrosion, which makes extreme accuracy and dependability unlikely, unless the equipment is checked at frequent intervals.

Because of these disadvantages millivolt instruments have been largely superseded in refinery practice by the more reliable potentiometer or "null" type temperature instrument, which opposes the unknown thermo-electric potential with a known battery potential. When balance is obtained on this system no current flows in the thermo-electric circuit. Hence, the accuracy of the reading is unaffected by variation in resistance of the lead wires.

The resistance pyrometer, while it has not come into general use principally because of its extreme delicacy, is of considerable interest. This instrument, which makes use of the temperature coefficient of resistance, characteristic of many metals, operates in conjunction with a Wheatstone bridge, and in this case the resistance of the heated metal is balanced against a known resistance. This instrument, like the millivolt meter, has the disadvantage in commercial use in that the accuracy of the reading is affected by the resistance of the leads. While it is possible to compensate for resistance changes due to change in temperature of the lead wires, the system is nevertheless subject to the influence of corrosion and loose connections.

Measurement of gas composition is an application to which electrical circuits are well adapted.

The thermal conductivity type of carbon dioxide meter incorporates a resistance pyrometer. This apparatus operates on the principle that the rate of heat conduction through all of the normal constituents of flue gas, except carbon dioxide, is substantially the same and considerably higher than carbon dioxide. A standard and a sample of unknown carbon dioxide content are each heated by platinum filaments which at any

given temperature have the same resistance. When the gas composition and consequently the thermal conductivity of the two samples are the same, the filaments attain the same temperature and have the same resistance, under which condition the circuit represents a balanced Wheatstone bridge. When the carbon dioxide content of the sample being analyzed differs from that of the standard, current flows through the galvanometer. On some instruments the galvanometer is graduated to read in percent carbon dioxide, while others through an auxiliary variable resistance maintain a balanced bridge at all times.

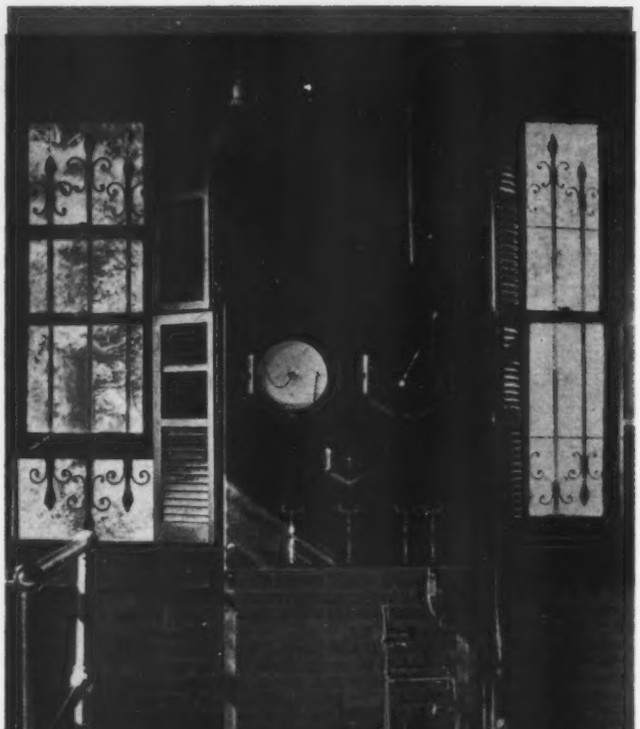
The oxygen alarm, operating in conjunction with the hydrogenation plant at Bayway refinery of Standard Oil Company of New Jersey, represents a very interesting and important application of electricity to the determination of gas composition. Because of the explosiveness of hydrogen-oxygen mixtures, the oxygen content of the gas used for hydrogenation must be kept under rigid control. In the oxygen alarm a small but representative sample of process gas is washed, dried, and passed through electrically heated porcelain tubes containing a platinum-black catalyst. The tubes are heated to a temperature of about 300° F. at which temperature and in the presence of this catalyst any oxygen present combines with the hydrogen to form water in a reaction which is highly exothermic. An accurate thermo-couple pyrometer records the temperature in the furnace and any increase in temperature due to the formation of water is immediately recorded on a scale graduated in percent of oxygen. The electrical energy generated in the thermo-couple by the heat of reaction actuates an electric alarm, which sounds in the control house, whenever the oxygen content of the gas rises above two tenths of one percent.

Many flow, level and pressure indicators and recorders in commercial service make use of electrical circuits for the transmission of measured data. In this way electric wiring is substituted for piping otherwise necessary and comparatively long distances between the point of measurement and the indicator or recorder may be spanned at relatively low cost. Electric transmission eliminates the difficulty of frozen lines, the hazard of ruptured piping, and greatly facilitates centralized control.

One of the most common of the electric flow meters

***Oxygen Alarm used in connection with Standard Oil Company of New Jersey, Hydrogenation plant at Bayway.***

utilizes an "inductance bridge" for transmission of the differential reading across an orifice. Distances of more than 200 feet are commonly traversed with systems of this type while a few installations have extended almost three quarters of a mile. The transmitter and receiver each comprise two identical coils connected in a manner similar to the four resistance legs of a Wheatstone bridge, each pair surrounding an iron core. As the core in the transmitter changes its position in the coils in response to a change in level of the mercury in the differential manometer, the circuit becomes unbalanced resulting in a force tending to move the core of the receiver, which is connected to the pen or pointer, to a similar position in relation to its coils, at which point balance is restored. Alternating current is used to energize the circuit and the accuracy of the reading is unaffected by even considerable variations in line voltage.



***Electric Telemeter.***
—Courtesy Builders Iron Foundry.

Another type of transmitting system, which bears a close resemblance to the one just described, is the self synchronous motor more commonly known under the General Electric Company's trade name of "Selsyn." The circuit of this system is so designed that when the position of the transmitting rotor is changed with respect to its stator windings a condition of momentary unbalance exists; and the difference in potential thus created results in a torque tending to move the receiving rotor to a position with respect to its stator winding corresponding to the position of the transmitting rotor. In its practical application to differential meters, the transmitting rotor is moved by a pulley arrangement connected on one end to a float on the mercury in the manometer chamber and connected on the other end to a counter-balancing weight.

"Selsyn" motors may also be applied to the transmission of power. These motors constitute the fundamental mechanism of the deFlorez remote control, which makes it possible to position valves at remote points on refinery equipment from a central control house. The transmitter in the control house and the receiver located near the control point are connected to the hand wheel and valve, respectively, through reduction gears. Since resistance to movement at the receiver, caused by the valve sticking, is translated into resistance at the transmitter, it is possible for the operator to "feel" the movement. This feature minimizes strain on the valve or mechanism in the event of impeded movement.

One type of instrument which has been used in refinery work utilizes what may be roughly characterized as a transformer circuit. The operating principle of this type may be illustrated by considering a core type transformer having a primary coil wound on one leg and an insulated chamber surrounding the other leg. When an electromotive force is impressed on the primary coil by an alternating current source, an ammeter or a wattmeter in the primary circuit measures the current flowing or the electrical energy dissipated, respectively, resulting from transformer losses. When sufficient mercury is in the chamber to form a ring around the core, an induced current flows which is inversely proportional to the resistance of the ring, neglecting primary resistance and eddy losses. The increased current flow necessitated in the primary corresponding to decreased resistance in the secondary, attending a rising mercury level, is measured by an ammeter when instantanous values are desired; while the energy input to the secondary, which is dissipated in the form of heat, is measured on a watt meter when an integrated reading is desired.

The manometer chamber of another instrument, which takes flow of electric current as an index of differential pressure, contains a series of metal rods of varying length connected to electrical resistances. The rise or fall of mercury in the contact chamber increases or decreases the current flow and in turn the meter reading in the instrument circuit. When applied to flow measurements, the resistances are so arranged that the conductance of the circuit corresponding to any given contact rod is directly proportional to the square root of the differential reading.

Instruments relating flow of electric current to differential reading require some means of compensating for voltage fluctuations on the power supply.

An instrument which has appeared on the market within the last two years, operates in conjunction with the telephone lines and makes possible the transmission

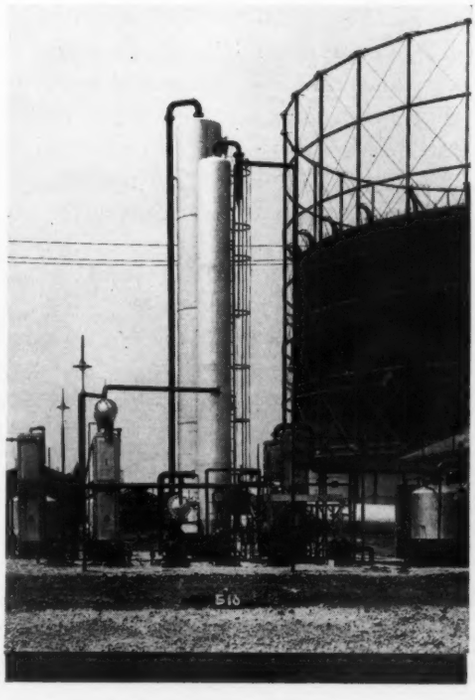
of measurements over several hundreds of miles. In one demonstration more than 400 miles were traversed with very satisfactory results. The transmitting apparatus consists of a telechron clock mechanism, so arranged as to control the time length of a direct current impulse through the transmitting line. The time length of this impulse is proportional to the magnitude of the value which is being transmitted. The direct current impulse is repeated every 60 seconds. For example, at one quarter of the maximum value of the quantity, the length of the time impulse is 15 seconds and during the remainder of the 60-second cycle no current flows. By means of a relay, synchronous motor and magnetic clutches, these impulses may be translated into chart pen position, indicator pointer position, integrated quantity or any desired combination of the three. This system, since it uses telechron clocks, is dependent only on the maintenance of constant current frequency and its accuracy of measurement is unaffected by ordinary variations in line voltage or current magnitude.

Since flow, level and pressure may all be measured with differential manometer, it is obvious that any of the previously described transmitting circuits will apply equally well in any one of the three special cases. Electrically transmitting level meters for tank gauging bears promise of considerable practical application, under conditions where the specific gravity remains fairly constant.

Inasmuch as the initial step in any control operation, either manual or automatic, consists in evaluating conditions at the control point, it naturally follows that any of the circuits previously considered as applying to indicators and recorders may be incorporated in automatic control equipment. An electric current may with equal ease actuate a recorder pen, an indicator pointer, or, through an electric relay and motivating medium, a control valve. The two mediums most generally used, in conjunction with the measuring mechanism, in automatic control equipment, are compressed air and electricity.

Under conditions where process time lag is slight or where reasonable variation from straight line control is permissible, an electric motor-driven two- or three-position valve will usually suffice. If process lag is considerable and straight line control is of extreme importance, as in the case of cracking coil outlet temperature, in order to minimize hunting or over-shooting, some form of analyzed control is necessary. In other words, the control mechanism must possess power of analysis comparable to human intelligence and in making adjustments take into account not only extent of departure from the desired normal but also rate of change. While the method of accomplishing this type of control may vary to some extent, in practically all cases it is required that the controlled valve be capable of assuming an infinite number of positions.

One type of electrically operated temperature control is designed to take into account rate of change and extent of departure through the use of two motors, an initial and a floating motor. The initial motor, so designated because it furnishes the initial check on temperature changes, makes comparatively large adjustments to oppose and arrest temperature trends as soon as they are detected. The floating motor takes smaller steps to compensate for changes in operating conditions. The frequency of its action is determined by the trend of the temperature change and the amount the temperature differs from the control point. This motor, which is intended to keep the temperature from hunting, derives its name from the fact that it assumes no definite position but floats throughout its range in order to maintain the temperature at the normal. The purpose of the initial motor is to maintain a uniform temperature regardless of whether or not this temperature is at the control point. It is the purpose of the floating motor to return the temperature to the normal. Hence, when due to some upsetting condition, the temperature is departing from the normal both motors make adjustments in the same direction, the initial motor operating to make the rate of change zero and the floating motor to return the temperature to the normal. When the deviation is arrested and the temperature starts to return the two mechanisms oppose each other, since the floating motor in bringing the temperature back to the normal is creating a rate of change, a condition which is always opposed by the initial motor. Thus, the temperature line tends to approach the normal tangentially and hunting is avoided.



Today, more than ever before, due to economic conditions and revised business policies, the refiner is confronted with the extremely difficult task of absorbing increased costs for labor and taxes without a corresponding increase in the sale price of his product. In attaining this end no field of endeavor appears more fruitful than that of rigid process control, since it permits optimum operating conditions at all times. In the achievement of efficient coordinated processing, electricity, because of its flexibility and adaptability, will undoubtedly play an important role.

# THE USE OF Explosion Resisting Equipment *in* Refineries

**V. R. CHADBOURNE**
***Chief Electrical Engineer,***
***Magnolia Petroleum Company,***
***Beaumont, Texas***

ELECTRICITY IN REFINERY OPERATION

ALTHOUGH Article 32 of the National Electrical Code has been in the regulations for some time, due to the fact that it has been necessary for the manufacturers of this equipment to design, build and test apparatus that would pass the rigid examinations of the underwriters for use in the locations as defined under this article, it is only within the past year that approved explosion resisting equipment in a variety of sizes has become available.

In the meantime there has been a growing demand on the part of insurance companies, safety organizations and regulatory bodies that industries having hazardous conditions should conform to the code in the use of explosion-proof and explosion-resisting equipment.

In this article the terms explosion-proof and explosion-resisting are used interchangeably as one or the other term is used by various manufacturers to designate similar apparatus approved by the underwriters for use in hazardous locations as defined in Article 32 of the National Electrical Code.

The oil industry is now confronted with the problem of replacing some existing electrical equipment with explosion-resisting devices in those areas considered dangerous. Just how far it shall go in doing so is hard to determine. As yet the use of explosion-resisting electrical equipment is limited by the fact that motors and control equipment in the larger sizes and higher voltages have not yet met the approval of the underwriters while only recently has it been possible to obtain suitable explosion-resisting lighting fixtures and panel boards.

Due to the fact that the cost of explosion-resisting equipment is on an average of from 60 to 70 percent more than standard equipment, no company can warrant the expense of a wholesale discarding of old equipment in favor of explosion resisting where there are areas that cannot under any circumstances be classed as hazardous locations or where there are areas whose possibilities of being so are debatable.

In all likelihood the continued use of approved explosion-resisting equipment will have a tendency through greater demand and thus greater production, to lower its price in relation to the standard equipment. The smaller this differential the more reason for making such equipment more universal throughout the properties of the company.

## HAZARDOUS LOCATIONS

The National Electrical Code defines generally a hazardous location for Class 1 under which oil companies are grouped as follows:

"Class 1 locations are those in which flammable volatile liquids, highly flammable gases, mixtures or other highly flammable substances are manufactured, used, handled or stored in other than their original containers."

It is evidently not the intention of the framers of this definition to mean that the whole area of a refinery be considered hazardous but rather those areas where flammable vapors are present at times or where there are great possibilities of such occurring through leakage or breakage. And it is of course not their intent to regard as hazardous locations all premises where flammable gases are used, as this would affect even ordinary dwellings.

It would be impracticable here to list as hazardous locations any parts of refineries as conditions and design of equipment vary so much in different plants that places of the same nomenclature may be very safe in one and very dangerous in another. Each location must be judged on its own merits by the inspection authority, as arrangement of buildings and equipment may greatly affect individual cases.

That this is the intention of the framers of the code is shown by the introduction of Article 32 as follows:

"The provisions of this article are intended to apply to locations in which the authority enforcing this code judges the apparatus and wiring to be subject to the conditions indicated by the following classifications. Where the apparatus and wiring are installed in rooms or sections of the building in which the particular hazardous conditions do not prevail, such wiring and apparatus may be of the type approved for such locations."

Thus to determine just what must be done in

order to keep installation and replacement costs as low as possible and yet at the same time provide the proper degree of safety in meeting insurance regulations, it would be well for any company before plunging headlong into such a safety campaign to make a survey of its properties with the view of determining in which of the following three classes they fall:

1. Hazardous;
2. Non-hazardous;
3. Debatable.

For any new installation in a location falling under the first class there should be no alternative, unless the apparatus desired is beyond the range of approved equipment, from installing equipment approved by the underwriters for service in such hazardous conditions.

The additional first cost of such equipment as compared to so-called standard equipment is not excessive when balanced against the considerations of safety or accident prevention, the safeguarding of property and the decrease in fire insurance premiums. Explosion-resisting equipment presents greater possibilities of safety to the operators than standard equipment. Any means of accident prevention is a saving in accident insurance premiums to the company as well as a humane act. In some instances the cost of such an installation is even less than standard equipment because the new equipment is weatherproof, thus eliminating buildings.

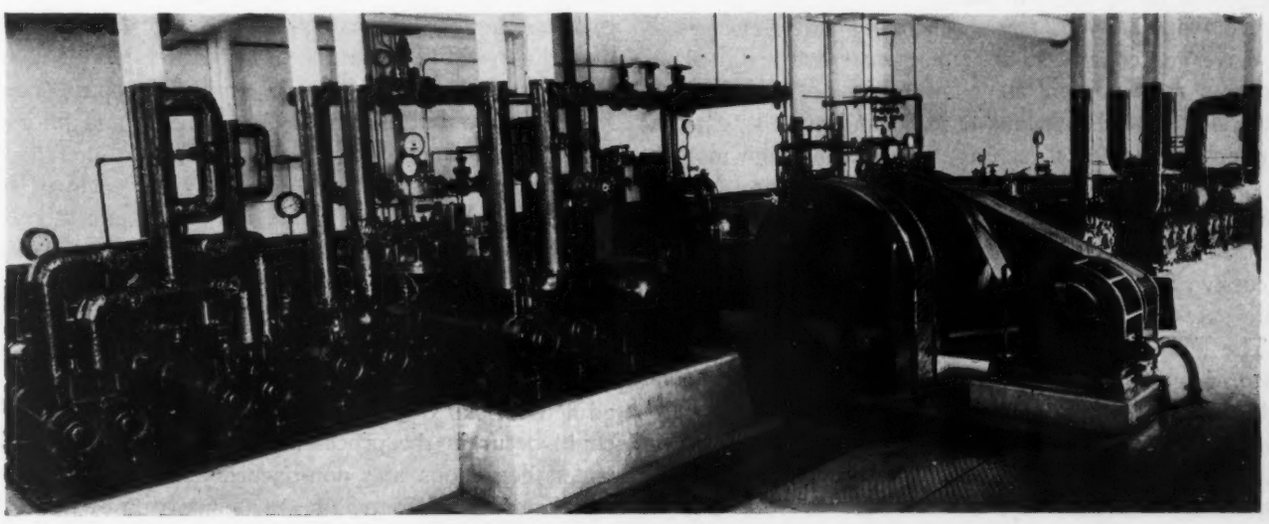
One of the causes of excessive repairs to open electrical equipment in all refineries is the corrosive effects of sulphuric and sulphurous gases. In those refineries where explosion-resisting panel boards have been extensively installed the resulting decrease in repairs from that cause has been gratifying. These gases also have a very detrimental action upon insulation and doubtless it will prove economical in the installation of new equipment to consider the use of explosion-resisting motors and starters in locations such as acid recovery plants or processes where acid gases are in existence.

However the problem becomes more complicated whenever there is a hazardous area with equipment which, while the best in its line when installed, now falls short of underwriters' standards. When the cost of replacing this with explosion-resisting equipment would be excessive, then it is a case of changing and improving conditions as far as possible. Usually a combination of methods can be found that will render the use of the old equipment safe and permissible and at the same time lower the insurance premiums. It is surprising to find that very often by a little thought and study a very hazardous location can be transformed in that respect to one of little or no hazard.

Buildings can be arranged for better ventilation by natural means or by motor driven fans; in many instances, especially in the warmer regions, buildings can be made of skeleton construction or can be completely done away with; basements can be eliminated and all apparatus placed on a plane or level such that no gas pockets can occur. Electrical apparatus such as controllers or motor starters can be removed to remote non-hazardous places without excessive expense while apparatus that cannot be moved can be ventilated by gas-free air pumped from without the dangerous area and kept under pressures sufficient to prevent infiltration of dangerous vapors. In some cases it might also be advisable to use some non-flammable gas such as carbon dioxide for cooling and ventilation. However, the use of these gases is expensive unless care is taken to prevent leakage.

Perhaps a few hypothetical cases will more readily show how these corrections can be made.

Consider first a case of a process where standard motors with standard controls drive high speed centrifugal pumps handling light oils at fairly high tempera-



***Motor driven pumps and compressors in a Pennsylvania cracking plant.***

tures. Motor rooms are poorly ventilated; pipe lines are run in conduits below floor levels; gas is usually present; lighting system is in good shape but not explosion-proof; motors are of such size that while they may be obtained explosion-proof yet starters of that size not approved. The inspector considers this a very hazardous location and makes the following recommendations which will make the process much safer besides simplifying the layout.

He recommends that some of the buildings be done away with entirely and as petroleum vapors are heavier than air that all depressions be back filled to one level to avoid any possibility of gas pockets; that all high speed pumps and standard motors with their control equipment be replaced with slow speed pumps and direct connected explosion-proof motors installed on the same bed plate; and that all piping be simplified and arranged on ground levels or elevated.

Due to the fact that it is impossible to obtain explosion-proof starters of the size needed, drastic changes in the electrical layout are recommended. As the code does not permit service entrance equipment in such an area unless of the explosion-resisting type and as it also recommends that motor controllers be of the remote type and be installed outside the hazardous location, the inspector considers that a well ventilated electrical control building housing all the service equipment and starters should be erected some distance away. Push buttons of the explosion-proof type are to be placed near the pumps. All motor conduits are to run underground with sealing condulets preventing passage of any gases through them. All local lighting is to be with explosion-resisting lighting fixtures, the system conforming to the code for hazardous locations with all general lighting done by flood lighting mounted well beyond the limits of the hazardous area. Portable lights to be eliminated in so far as possible while those extension cords necessary are to be of the approved type with explosion resisting receptacles.

Consider next another hypothetical case which must be solved in a different manner. This is a problem where a number of large synchronous motors are used to drive gas compressors. The motors are installed in separate rooms from the compressors. The inspector considers this a hazardous location and must lessen the danger of the use of such apparatus. Although motors of this size can be obtained in an explosion-proof type, none have been approved by the underwriters. The company feels that the cost of such a change would be excessive and asks for some cheaper and at the same time safe alternative.

The inspector then considers the installation of motor-driven centrifugal compressors taking suction outside of the gas area. This air will be forced into the motor rooms at a pressure sufficient to overcome any explosive gas infiltration. The system will be electrically interlocked whereby the synchronous motors cannot operate unless the air compressors are operating; and should the air pressure in any motor room drop below the desired pressure an alarm will be sounded and that set of apparatus disconnected automatically.

Should the ventilating air give trouble in certain seasons of the year by containing excessive moisture it can be heated sufficiently by waste heat from other parts of the process to prevent condensation in the apparatus ventilated.

This recommendation is safe and permissible besides costing less than a complete change over to explosion-resisting equipment.

The operators of a cracking unit complained that the control house was habitually gassy. This was found to be leakage from the packing glands of the reflux pumps. As a precaution against fire and explosion these units were moved out of doors. As they were equipped with explosion-proof motors no building was necessary. This arrangement cleared the house of gas, lowered the temperature to a more pleasant one for the operators, corrected a dangerous situation and made maintenance and repairs easier because of greater accessibility.

Still another type of problem is where the inspector finds all the equipment to be explosion-proof yet there is a possibility of an accumulation of explosive vapors. In this case, where added artificial ventilation is impractical, he must recommend the removal of portions of the buildings to effectually prevent such occurances.

Locations found in the survey to be in the non-hazardous class would not require any changes in existing equipment provided of course there is no likelihood of conditions changing.

Locations of this nature are the repair shops, offices, boiler houses and what might be called the indirect part of the oil manufacturing process as drum factories, cooper shops and those portions of the works used for renovation or construction of equipment.

However, before a new installation in a non-hazardous area is undertaken it will be well to consider whether this particular area might not at some future time change its conditions to that of more hazardous ones.

Sometimes where equipment is not continuously required it might be worth while to install explosion-resisting motors and controls with the understanding that these would serve as spares or replacements for those in hazardous locations. In various parts of oil refineries are areas such as clay burners and filters in which large quantities of dust are encountered. In these it is considered good policy to use enclosed-fan-cooled type motors. It would not be an excessive expense to make all new installations and replacements explosion resisting. By so doing it might be possible to carry a lesser stock of spares.

In all oil refineries there are numerous areas or locations which while not properly hazardous yet due to adjacent risks or to very remote contingencies which could occur in the process, are in the border land between hazardous and non-hazardous. In this class of locations will be found the greater portion of the lighting equipment of the refinery. What type of fixtures shall be used? For instance, on still furnaces it is cus-

tomary to use largely vapor-proof equipment, thus arguing that explosive vapors are present. Yet it would seem ridiculous to equip such a location with expensive explosion-proof fixtures when the furnace fires would surely ignite any gas should a leak occur. There are numerous storage rooms in any large refinery where case goods or drums are stored awaiting shipment and where no oils are handled except in sealed containers. Should such equipment be explosion-proof? The majority of operators doubtless would argue it a waste of money while on the other hand the insurance inspectors could argue with as much plausibility that a potential hazard existed which warranted its installation. Probably a decision in a case of this sort would depend upon whether or not the oils in storage were of a very volatile nature.

Just what must be done in these areas will depend to a great extent upon company policy. If the officials lean to the side of playing safe regardless of cost, the answer is that such portions of the properties will be equipped with approved explosion-resisting machinery. On the other hand if they are inclined to analyze costs and study the chances of outages to be incurred from fire or explosion they will probably weigh the additional costs of explosion-resisting against saving in fire insurance premiums as the result of using this equipment.

Undoubtedly new installations in such areas will show savings when explosion-resisting equipment is used; the revamping or retiring of old equipment will follow no fixed rule but will depend upon local conditions.

But after all the installation of approved explosion-resisting equipment is not a cure-all and money so spent will yield disappointing returns in many instances. Too often operators as well as insurance inspectors themselves take for granted the safety of devices every bit as dangerous as the motors and starting equipment that are replaced at a great cost.

Mechanical hazards, as belts generating static charges, high speed pump packing so hot as to nearly blaze and uncovered hot tar lines, are not uncommonly found in hazardous locations. Why then install expensive electrical equipment when dangers just as great, although not so apparent, exist.

## LIGHTING

So far little has been said about lighting installations. If all hazardous locations are to be equipped with explosion-resisting motor equipment, surely in those areas the installation should be complete in all respects. Particularly the lighting system must not be overlooked. If motor equipment of the approved type is installed it is just as essential that the lighting be installed as the code demands.

One of the greatest potential dangers in any lighting equipment is an extension cord. This is recognized in the code where it is recommended that portable lamps be eliminated in so far as possible. Although explosion-proof lighting units are expensive, if by installation of additional ones portables may be done away with, it will be worth while. Any new installation should be planned so that sufficient illumination is provided to make the use of portable lamps or extension cords unnecessary.

Where their use cannot be eliminated in a hazardous location, the greatest care must be taken in installation. It is essential that only approved cords be used with a grounding connection provided. If they can be connected permanently so much the better. If that is not possible, the receptacles and attachment plugs must be either interlocked with the switch, preventing the plug from being removed when the current is on or they must be of approved devices which seal the arc when the current is interrupted.

In any installation of explosion-resisting equipment good workmanship and good inspection are vital requisites. It is essential that the installation follow the proscribed code or its benefits are lost.

In a supposedly explosion-proof installation in a gaseous area a standard condulet was used just ahead of an explosion-proof push button. Here was a case of a $5000 job rendered ineffective by poor workmanship and poor inspection.

In another instance where standard motors had been replaced by explosion-proof ones in a hazardous area the connections to the motors were in flexible conduit, no sealing condulets were used and the switches, while oil immersed, were not of an approved explosion-resisting type.

Such examples as cited must be watched for carefully on any installation in a hazardous location where a single flange not properly fitted or a sealing condulet omitted makes the entire expensive job no better than good standard equipment.

Doubtless it will take some time to make operators and inspectors appreciate the fact that in a partially explosion-proofing a location they have gained but little. The old adage still holds true that "A chain is no stronger than its weakest link."

Under the code the authority enforcing it is definitely charged with the responsibility of determining the existence and extent of the hazardous areas. In most refineries this means that those in charge must decide for themselves what are the hazardous locations in the plant. Consequently the management should insist that a survey of the properties by those qualified to do so should be made with the view of designating such areas. As conditions change from time to time new surveys should be made periodically.

To summarize briefly it seems that all new installations in hazardous and debatable areas should be of explosion-resisting equipment and that all existing equipment in hazardous locations be either replaced by explosion-resisting devices or made equally as safe by changing conditions. The use of existing equipment in debatable areas together with new and existing equipment in non-hazardous locations should be governed by local conditions.

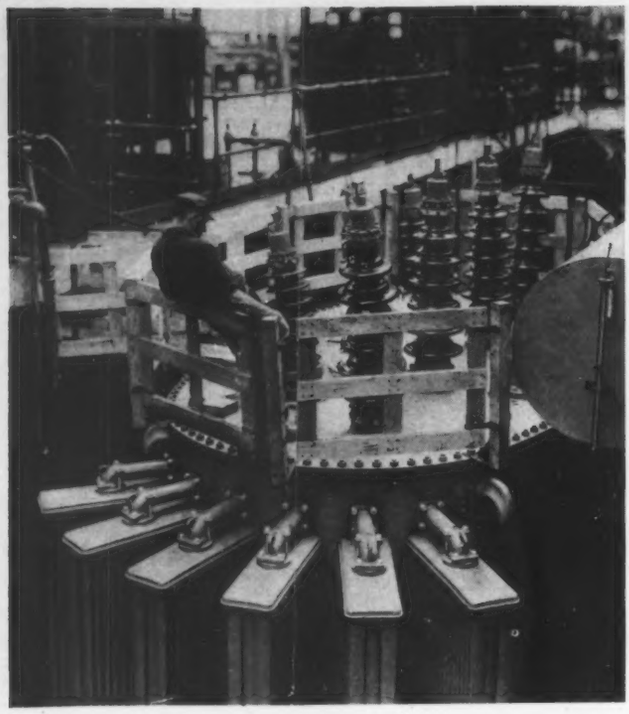


**FIGURE 4**

***Portable sectional fence for preventing falling from top of tall equipment.***

# Automatic and Electrical

**J. V. ALFRIEND, JR.**
***Industrial Engineer, Westinghouse Electric & Manufacturing Company***

***A paper presented before the National Safety Council Convention, Chicago, Ill., October 2-6, 1933.***

PROBABLY the most spectacular hazard in the chemical industry is the explosion of gases ignited by electric sparks. One such explosion can wreck a plant and kill or maim dozens of men. The production of films, of cellophane, of alcohol and of gasoline are typical of industries where motor drives must operate in explosive gas mixtures. The explosion resisting motor was developed to eliminate this hazard. Such a motor must of necessity be enclosed so as to prevent the ignition of a gas mixture outside the case from an explosion inside the case. Three constructions are available—totally enclosed, totally enclosed fan cooled, and totally enclosed pipe ventilated. The first is practical in small and slow speed ratings but becomes prohibitive in cost in medium sizes and impossible to build in the larger ratings. The last is applicable in a relatively few cases and then only when the number of units installed is low.

The fan cooled construction is practicable from medium size motors of two horsepower up to 200 horsepower. Built in accordance with the specifications of the National Board of Fire Underwriters and approved by them for Class 1 Group D atmospheres this motor insures adequate protection in all conditions coming under that classification.

This is called the heat exchanger or dual ventilated construction. By circulating the internal air through ducts in the frame adjacent to ducts for the external air the rotor heat is disposed of without large temperature gradients and with complete elimination of hot spots.

The gases escaping after an explosion within the motor must escape through the bearings or through the ground metal fit of the brackets to the frame. The cooling thus obtained has been proven by actual test in the Underwriters Laboratory to prevent ignition of the atmosphere outside of the motor. Figure 1 shows an installation of this type of motor in an oil refinery.

Many combinations such as multi-speed drives using a variable ratio set of gears, a pole changer motor or a combination of such a gear motor with multi-speed drive to obtain very slow speeds and several of them from a single unit.

Probably the second most common hazard is that due to fires originating from the operation of circuit interrupting devices. Since the discovery of the De-ion principle of current interruption Westinghouse has been rapidly developing air circuit breakers to apply to all feeder and power circuits and to eliminate the hazards of the older types of construction.

The Nofuze switch unit shown in Figure 2 is a small De-ion circuit breaker for lighting circuits. There is no temptation to wire around the device when a refill is not handy—being a circuit breaker one has simply to reclose it to make the circuit operative. If the fault has not cleared there will be no burned fingers—the device is trip free in all positions. Furthermore accidents are prevented by the short time necessary to restore lighting service. The position of the handle shows which switch has operated. Movement of the handle to the "off" position resets the device then to the "on" position and service is restored in less time than it takes to tell about it.

The ABI De-ion circuit breaker has been developed for industrial feeder circuits. This switch has opened short circuits of 10,000 and 20,000 amperes on 440 volts without setting fire to absorbent cotton with which the case was wrapped for the experiment. Figure 3 shows a group of these switches.

And the father of them all is the type U De-ion circuit breaker. Different in appearance and con-

# Remote Control of Equipment Operations

## *from a Safety Standpoint*

ELECTRICITY IN REFINERY OPERATION

struction—the same in principle of arc extinction these circuit breakers open power faults of 500,000 to 1,000,000 arc kv-a. in less than three cycles after the occurrence of the fault. With no oil to throw during the tremendous electrical stresses involved there is no possibility of setting fire to the station.

The number of electrocutions in chemical plants from operators and laborers coming in contact with live circuits is beyond estimation. This type of hazard falls into two classes: Accidental contact with known live circuits, and contact with supposedly dead circuit.

The first form of hazard is entirely eliminated by the use of "dead front" control and switchboards. All power circuits are behind the board—all operating handles are "dead." Not even deliberate suicide is possible from the front of the board.

The supposedly "dead" circuit may be protected against by one of the forms of metal-clad switchgear known as "lift up" or "roll out." In the former the circuit breaker is lowered from engagement with stationary contacts (only possible with the circuit breaker in the open position) and the unit removed from its compartment where it may be worked on with all possible safety. No one can close these disconnects while the operator is working on the breaker for the disconnects are the terminals of the breaker. The "roll out" equipment is similar except that, as the term implies, the movement of the unit to disengage the stationary contacts is horizontal instead of vertical.

The liability of transformer fires resulting from lightning disturbances has recently been reduced to the minimum by the development of Surge Proof transformer. This design is capable of withstanding direct strokes of lightning without puncturing the insulation. In this design the insulation of the windings is correlated with the insulation of the terminal bushing or with a special form of lightning arrester in the transformer so that the surge will jump across the terminal bushing to ground or across the arrester before it will puncture the insulation. In order to improve the transformer insulation to this extent creepage paths had practically to be eliminated because, strange as it may seem, increased creepage distance does not increase the resistance to surge voltage in anything like the ratio encountered in the less steep wave fronts of 60 cycle voltages.

The most fool-proof equipment that the manufacturer can devise can be made death traps by thoughtless or careless installation. Many a control board has been installed on the rotational center-line of the driving or driven equipment or where a broken belt might kill or injure the operator. Operating and control stations should be placed in the most secure of positions considering the mechanical, electrical

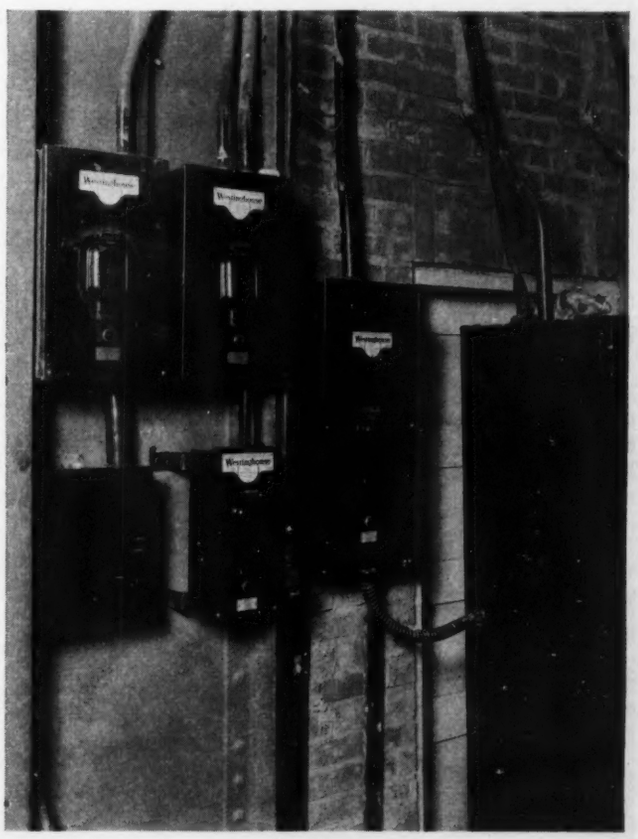


**FIGURE 3**

***ABI De-ion circuit breaker developed for industrial feeder circuits.***

and fire hazard. In other words, the control equipment should be located at a place where men in danger will naturally run to rather than run from. This is made possible only with electrically operated devices such as circuit breakers and contactors. Main circuits must be kept close to the equipment but control circuits for the operation of these devices may be conveniently and economically run almost anywhere. The use of a multiplicity of stop stations is most advantageous.

A foot or body operated emergency stop push-button should be located at a machine which is liable to entangle an operator's hands. A second stop station should be close by the machine but safe from it. A third stop station should be located at the supervisor's desk which should be protected from the operating room by safety glass. Here also should be located an emergency switch to shut down the entire plant.

In some rare instances it is necessary to place the control in a room separate from and protected from the hazards of the operating room. Such a control station must have a clear view of every operating equipment and must be capable of complete control of each individual item.

The use of such simple contrivances as door switches seems hardly worth mentioning yet I doubt if there is a plant in the country where one or more could not be used to eliminate a serious hazard. Any section, compartment or bin where electrical power must be removed for the operator's safety should not be protected by disconnect switches and a sign warning against the closure of the switch. The door to such an enclosure should be wired with a low voltage control circuit so that while that door is open no circuit breaker or linestarter or other switch may be closed and that door may not be closed without the key which is in the possession of the man who is in that compartment. There are many types of this sort of protection. In the Corey Interlock the key is kept in the lock of the circuit breaker which cannot be closed unless the key is in place and the key cannot be extracted unless the circuit breaker is open. The same key is then used to unlock the door—which door cannot again be locked without the same key. This sounds complicated but it is worth a life.

Just as it is the unloaded pistol that does the most damage so also is it the "dead" circuit that causes the most deaths. In plants with hundreds of feeders in one of the many forms of networks to improve regulation it is difficult indeed to prevent sneak circuits with certain combinations of open and closed switches. Sad to relate the unlucky combination does not always occur on the test at the completion of the new installation. To avoid this there is only one recourse—careful wiring diagrams, carefully checked and careful workmanship. An aid to this end is the purchase of factory assembled combinations of control. One type of cabinet contains the control and feeder circuit switches for the seven motors of a pair furnace. The only wiring necessary in the field is the connection of the power leads to the incoming terminal block and the connection of the seven motors to the terminals provided therefor. Fortun-

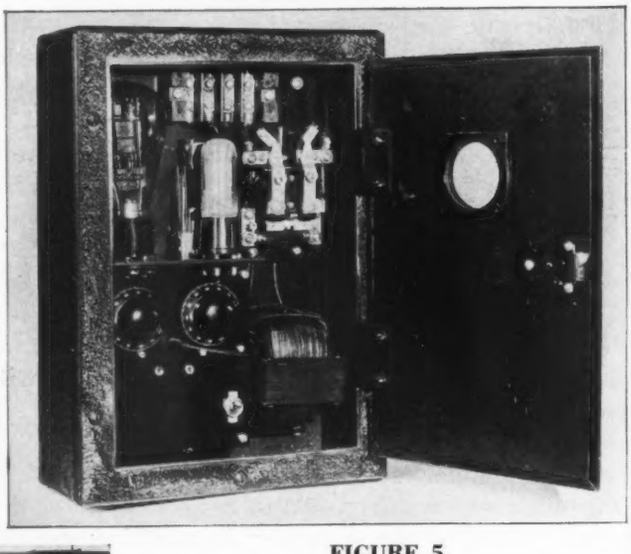


**FIGURE 5**

***The Photocontroller is a standard device for the control of electric circuits at the demand of a beam of light.***

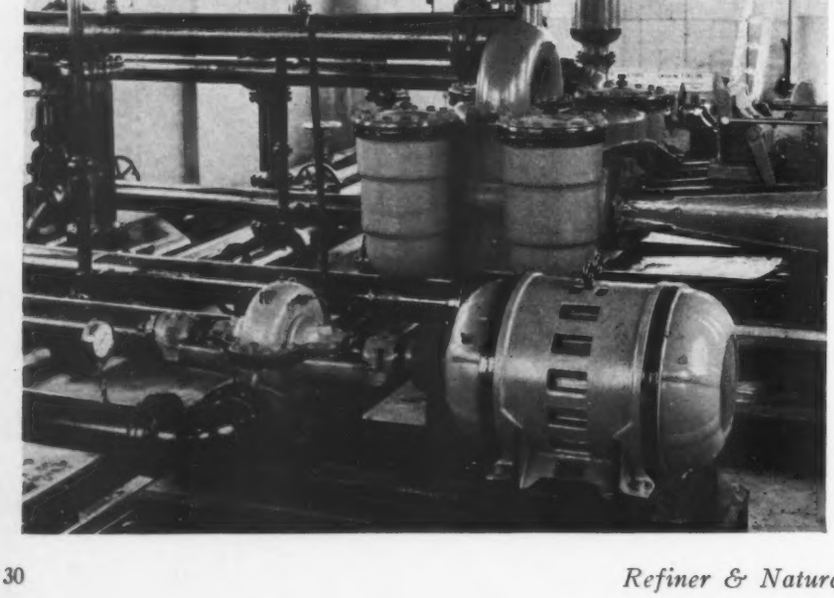


**FIGURE 1**

***Dual ventilated explosion resisting motor driving centrifugal pump in a refinery.***

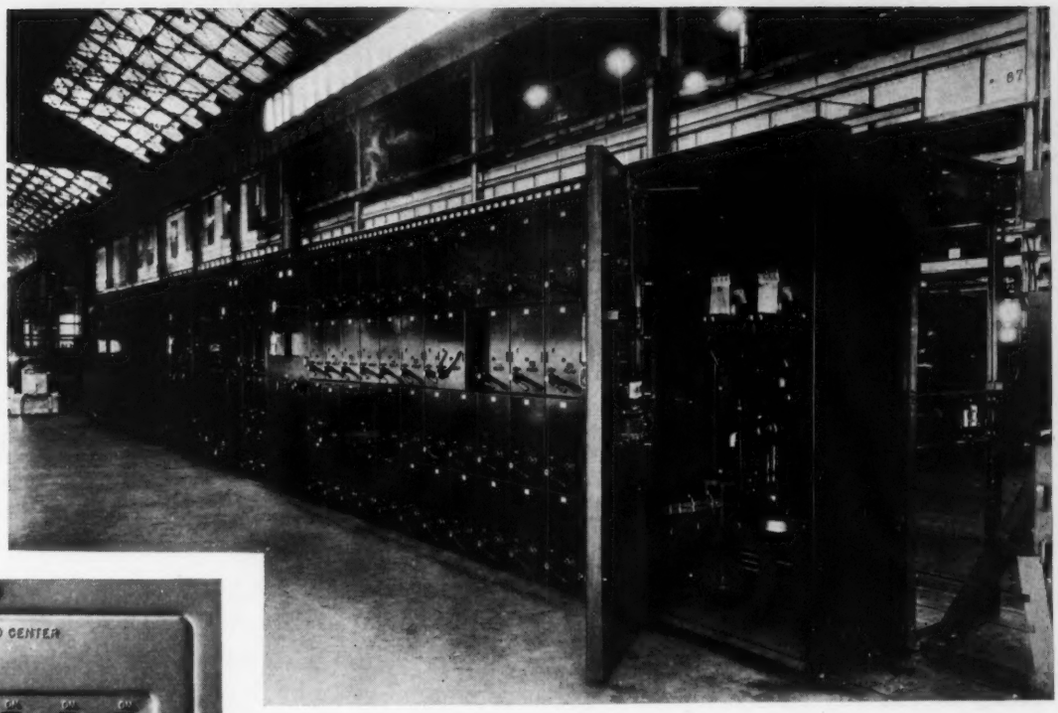


**FIGURE 6**

***A roll out carbon circuit breaker installation.***

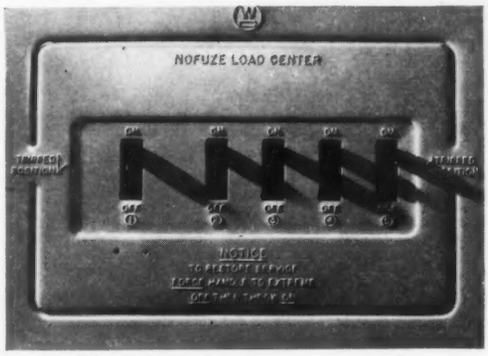



**FIGURE 2**

***Nofuze switch unit, which is a small De-ion circuit breaker for lighting circuits.***

ately the savings made in space and installation cost are more than sufficient to pay for the increased purchase price of such units.

Many hazards exist which are not subject to elimination by the selection of suitable equipment or by the most careful installation.

In our transformer test department we were menaced by the danger of men falling off the top of transformers when making connections for a test. Safety belts could not be used. The same problem may be met with in many plants in the care and maintenance of any large transformer, tank or bin.

We solved the problem by building a portable sectionalized fence as shown in Figure 4. The posts are held to the transformer by means of the cover bolts and the short sections supported by L-shaped bolts in the posts. By making the sections of one standard short length the economy of duplication is obtained and the assembled fence fits any shape of transformer sufficiently well to prevent an accident.

We cannot prevent a man from deliberately walking into danger nor can sufficient guards always be employed to save fingers, hands or arms. But we can disconnect power and apply brakes when a man approaches or enters the danger zone. The photo tube or electric eye has made this possible and the development of the Phototroller has made it practical.

The Phototroller (Figure 5), is a standard device for the control of electric circuits at the demand of a beam of light. So long as the photo tube is illuminated nothing happens. The instant anything intervenes between the light source and the tube cutting off the illumination the photo tube plate current changes and the circuit operates to open circuit breakers or motor starters, to apply brakes or to sound warning signals.

A somewhat similar protective device pays dividends in addition to saving lives. Records have proven that adequate illumination reduces accidents, decreases spoilage and increases production. But adequate artificial illumination costs money in electric power consumed, in replacement of bulbs and in supervision. By the installation of a lighting control unit the illumination may be maintained practically constant regardless of the variations in natural illumination. The photo tube in the control units responds to the illumination at the working level. If this is deficient the electric lights are turned on—if excessive they are turned off.

This paper started out with the prevention of fires and explosions—it is therefore fitting that it should end with the extinction of fires.

The smoke detector also uses a photo tube for the reduction of a hazard. A slight wisp of smoke coming between the light source and the photo tube is sufficient to set up the circuit for the ringing of alarms or the operation of a sprinkler system.

Truly it can be said that the photo tube is the safety engineer's "electric eye" for danger casts its shadow before an injury occurs and the shadow falling on the photo tube can instantly set in motion alarms or corrective measures.

# *The Design of* Fractionating Columns *Entrainment and Capacity**

MOTT SOUDERS, JR.,
*and*
GEORGE GRANGER BROWN
*Department of Chemical Engineering, University of Michigan.*

THE capacity of a fractionating column may be limited by the maximum quantity of liquid that can be passed downward or by the maximum quantity of vapor that can be passed upward, per unit time, upsetting the normal functioning of the column. The liquid capacity is determined by the capacity of the weirs and downspouts, but if the resistance to the flow of vapor through the plates exceeds the available head of liquid between plates the normal flow of liquid is interrupted and the column is said to prime. The vapor capacity is usually below the priming point and is limited largely by the quantity of entrainment that may be tolerated. For this reason if the column is of good mechanical design and has adequate liquid capacity, vapor capacity as limited by entrainment is the controlling factor determining column capacity.

## NATURE OF ENTRAINMENT

In a fractionating column, entrainment signifies the upward displacement of liquid particles, from plate to plate, caused by the dynamic action of the vapor. Entrainment may be regarded as the sum of two distinct effects of the flowing vapor, the actual carrying of droplets by the rising vapor and the throwing of liquid particles by the dynamic action of vapor jets. The first effect is a function of the mass velocity of the vapor, the densities of the liquid and vapor, and the diameter of the particle which in turn is influenced by the surface tension of the liquid, density of the vapor and agglomeration of individual particles into larger masses. The entrainment produced by the throwing of liquid particles is a function of the kinetic energy of the vapor jets, which, in turn, depend upon the density and the linear velocity of escape of the vapor; and is closely related to the spacing between plates.

## VAPOR CAPACITY OF A COLUMN

*Theoretical Suspending Velocity.*

The upward velocity of a fluid required to suspend a body in the fluid stream may be determined from the resistance of the body to the moving fluid and the force of gravity on the body.

The resistance of a sphere in a moving fluid is given by the expression[3].

$$F_a = K\mu\frac{\pi^{1/2}}{2}Dv + k\,d_2\frac{\pi D^2 v^2}{4} \qquad (1)$$

where $F_a$ = total force on drop
K and k are constants depending on shape of body
$\mu$ = viscosity of fluid
D = diameter of particle
$d_2$ = density of fluid
v = linear velocity of fluid relative to drop.

In a fractionating column the first term on the right may be neglected since the viscosity of the vapor is small (0.01 to 0.001 centipoises), so that

$$F_a = \frac{k\,d_2\pi D^2}{4}v^2 \qquad (2)$$

The force of gravity (less buoyancy) on a spherical particle,

$$F_g = \frac{\pi D^3}{6}(d_1 - d_2)\,g \qquad (3)$$

where
$d_1$ = density of particle
g = acceleration of gravity

When the force of gravity is equal to the resistance to the moving vapor, the particle remains suspended;

$$F_a = F_g = \frac{k\,d_2\pi D^2}{4}v^2 = \frac{\pi D^3}{6}(d_1 - d_2)\,g$$

and the suspending velocity,

$$v = \left(\frac{2\,gD\,(d_1 - d_2)}{3\,K\,d_2}\right)^{1/2} \qquad (4)$$

If D and k are constants

$$v = B\left(\frac{d_1 - d_2}{d_2}\right)^{1/2} \qquad (5)$$

$$B = \sqrt{\frac{2gD}{3k}}$$

v = linear velocity of vapor—feet per second.

*Published in cooperation with Industrial and Engineering Chemistry and the American Chemical Society.

## TABLE 1

| GENERAL DESCRIPTION | Column Pressure Lbs. per Sq. In. abs. | Plate Spacing Inches | Surface Tension of Liquid on Plate dynes/cm. | Observed "C" in mass vel. equation |
|---|---|---|---|---|
| Commercial alcohol-water column | 20 | 12 | 60 | 260 |
| Commercial pressure distillate rerun column | 55 | 12 | 13 | 235 |
| Commercial vacuum column, gas oil overhead | 0.96 (50mm) | 16 | 23, | 430 |
| Commercial natural gasoline stabilizer | 155 | 16 | 9 | 385 |
| Commercial natural gas absorber | 190 | 21 | .. | 330—400 |
| Commercial natural gas absorber | 465 | 21 | .. | 330—400 |
| Semi-plant gas oil vacuum column | 0.192 (10mm) | 22 | 25 | 595 |
| Commercial pressure distillate rerun column | 20 | 22 | 19 | 630 |
| Commercial topping column, gasoline overhead | 20 | 22 | 19 | 660 |
| Commercial cracking plant column, pressure distillate overhead | 50 | 22 | 14 | 550 |
| Semi-plant gas oil vacuum column | 0.383 (20mm) | 24 | 24 | 635 |
| Commercial natural gas absorber | 465 | 24 | .. | 355—440 |
| Commercial vacuum column, gas oil overhead | 0.632 (33mm) | 30 | 24 | 690 |

Since mass velocity of the vapor $W = 3600\ vd_2$ in pounds per square feet per hour,

$$W = C\,[d_2(d_1 - d_2)]^{1/2} \qquad (6)$$

$C$ = a factor depending upon conditions
$d_2$ = density of vapor—lbs. per cu. ft.
$d_1$ = density of liquid—lbs. per cu. ft.

*Practical Modifications.*

The range of sizes of the liquid particles which compose the entrained liquid is an indeterminate variable. Particle sizes probably are related to the surface tension of the liquid on the plate since the dispersion of the spray produced by a bursting bubble appears to vary inversely with the surface tension of the film. Increase in density of the vapor also appears to promote atomization.[4] The tendency for individual particles to coalesce into larger drops which are less readily entrained may be influenced by surface tension, and spacing between plates, or time, which may have a bearing on the probability of collisions between particles.

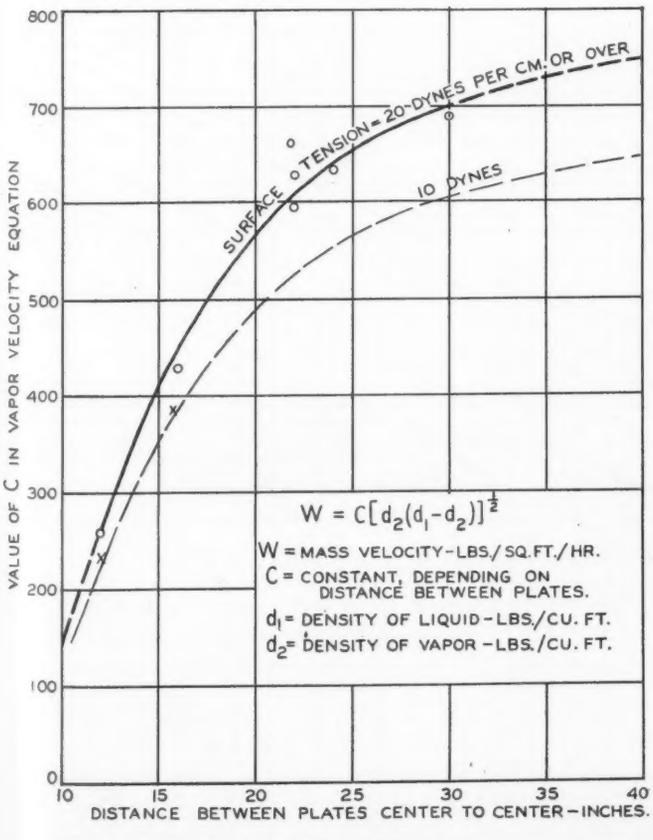



FIG. 1 EFFECT OF PLATE SPACING

In addition to the carrying of droplets by the rising vapor, entrainment is produced by the jet action of the vapor caused by the contraction of the path of flow through the bubble caps and vapor-liquid mixture on the plate. The throwing of droplets by vapor jets is related to the density and velocity of the vapor flowing through the slots in the bubble caps and the depth of the "liquid seal." In general, the penetration of droplets thrown by a jet decreases and the dispersion increases with increase of the density of the vapor.[4] With other conditions constant (velocities, densities, surface tension, etc.), it appears that the entrainment due to the throwing of droplets should be influenced largely by the distance between plates.

Increasing the velocity of the vapor through a column not only tends to increase the height to which droplets may be thrown but also decreases the free space above the vapor-liquid mixture on the plate. This effect is due to the vapor-lift action of the flowing vapor which raises the froth level as the velocity is increased.

*Evaluation of the Factor C.*

Table 1 presents data from a number of commercial fractionating columns operating at approximately the maximum vapor load compatible with satisfactory products. The operating data include conditions from 10 mm. of mercury to 465 pounds (0.013 to 32 atmos.) total pressure, 12 to 30 inches plate spacing, and materials from lubricating oils to natural gasoline. In each case the value of the factor "C" has been calculated by means of Equation 6.

In Figure 1, the values of "C" thus obtained are plotted against the center-to-center distance between the bubble plates. Points where the surface tension of the liquid on the plates is above 20 dynes per cm. (plotted

as circles) define the solid curve; points where the surface tension is less than 20 dynes suggest the location of the dotted curve for surface tension of 10 dynes.

In Table 1 the gas absorbers show a smaller allowable mass velocity, indicated by a smaller value of "C," since here any entrainment results in a direct loss of absorbing oil and a contamination of the dry gas causing difficulties in the gas lines, and such equipment must be designed for much lower vapor velocity[1] than fractionating columns, in which limited entrainment can be tolerated.

Figure 2 is a chart for evaluating the allowable mass velocity of the vapor in a column from the liquid and vapor densities and the value of "C" obtained from Figure 1. For example, in a topping column with gasoline overhead, $d_2$ is 0.094 and $d_1$ is 39.55 pounds per cubic foot, so that $d_2(d_1 - d_2)$ is 3.7. With plates spaced at 24 inches, C (from Figure 1) is 640 and (from Figure 2) W, the allowable mass velocity of the vapor, is 1200 pounds per square foot of column cross-sectional area, per hour.

It should be noted that all material comprising the vapor stream (including products, internal reflux, fixed gases, and steam) must be included when calculating the density of the vapor and the vapor load of the column.

## QUANTITY OF ENTRAINMENT

Data on the quantity of entrainment are meager. Chillas and Weir[2] reported the quantity of entrainment as a function of the superficial linear velocity of the vapor for an air-water system at atmospheric temperature and pressure with plates spaced 16 inches center to center, using a constant ratio of liquid to vapor. Comparable data on other systems with various plate-spacings and reflux ratios are much needed.

*Straw Oil System:*

Data were obtained in a semi-plat vacuum column with 30-inch plate-spacing on a straw oil vapor-liquid system at 10 mm. and at 20 mm. total pressure. Entrainment was estimated colorimetrically by the use of a non-volatile dye in the feed to the column. Although, plotting quantity of entrainment against mass velocity of the vapor, there was considerable scattering of the points, it was possible to draw a representative curve for each operating pressure.

*Comparison between Air-Water and Straw Oil Systems.*

Comparison between data on the quantity of entrainment obtained under conditions of different liquid and vapor densities, and in different apparatus with different spacing between plates, requires a general equation properly evaluating the effect of these variables. The data of Chillas and Weir on the air-water system and the vacuum column data on the straw oil system were compared using the velocities obtained from the constant C corresponding to the different plate spacings (Figure 1) as the basis of comparison. In Figure 3, quantity of entrainment, expressed as gallons at plate temperature of entrained liquid per pound of dry vapor, is plotted against the ratio of the observed mass velocity to the mass velocity calculated from Equation 6 and Figure 1.

Since the quantity of liquid flowing across the plate




FIG. 2

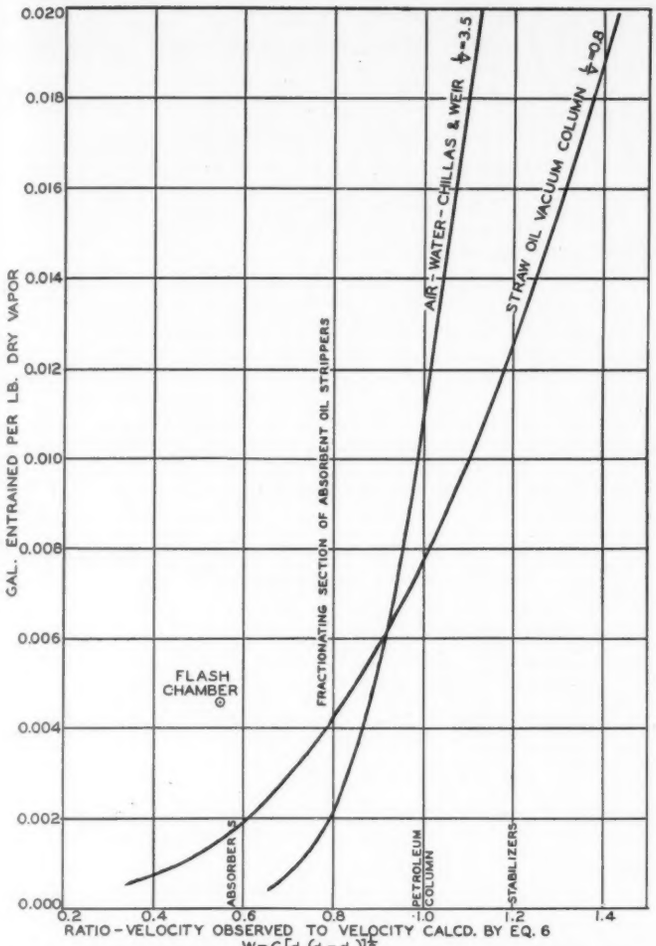



FIG. 3 EFFECT OF VAPOR VELOCITY ON QUANTITY OF ENTRAINMENT

varied with the mass velocity of the vapor (constant liquid-vapor ratio) the data on the two different systems were also plotted (Figure 4) as gallons of liquid entrained per gallon of liquid overflow against the ratio of observed mass velocity to mass velocity calculated by Equation 6 and Figure 1.

Both Figure 3 and Figure 4 show reasonably satisfactory correlation within the limits of accuracy of the experimental data and variations in the mechanical details of the apparatus. More experimental work is required to indicate the effect of vapor-liquid ratio and quantity of liquid flowing across the plate, in order to establish a wholly satisfactory basis of correlation.

The limits of operating velocities for fractionating columns in various services are indicated on Figures 3 and 4. These limits are for average conditions of operation and are subject to variations in mechanical design, in vapor-liquid ratio, and in allowable quantity of entrainment.

*Flash Chambers.*

Although this discussion deals exclusively with plate fractionating columns, it is well to indicate that much greater entrainment may be expected in other types of equipment which do not contain plates or other types of entrainment separating devices. The circled point in Figure 3 represents actual entrainment obtained in a flash chamber of a cracking plant and indicates an actual entrainment in this equipment free of any entrainment separating device more than twice that observed in a plate fractionating tower. The vapor-liquid mixture in this case entered the large chamber through a single pipe at high velocity, and the large kinetic energy of this stream was an important factor in increasing the entrainment over that of a plate column although the stream was directed against the lower end of the side of the chamber.

## EFFECT OF ENTRAINMENT

The effects of entrainment in fractionating equipment are largely the impairment of color, decrease in plate efficiency, loss of liquid overhead as in oil absorbers, and increase in the quantity of liquid flowing from plate to plate due to abrupt changes in vapor load.

*Effect on Color.*

The effect of entrainment on color is most important in flash jugs or chambers without fractionating plates since a small quantity of dark residual material may have relatively large effect on the overhead material. In fractionating columns where several plates separate bottoms and overhead, the effect of entrainment on color is less important since each plate acts as an entrainment separator and the dark material is pro-

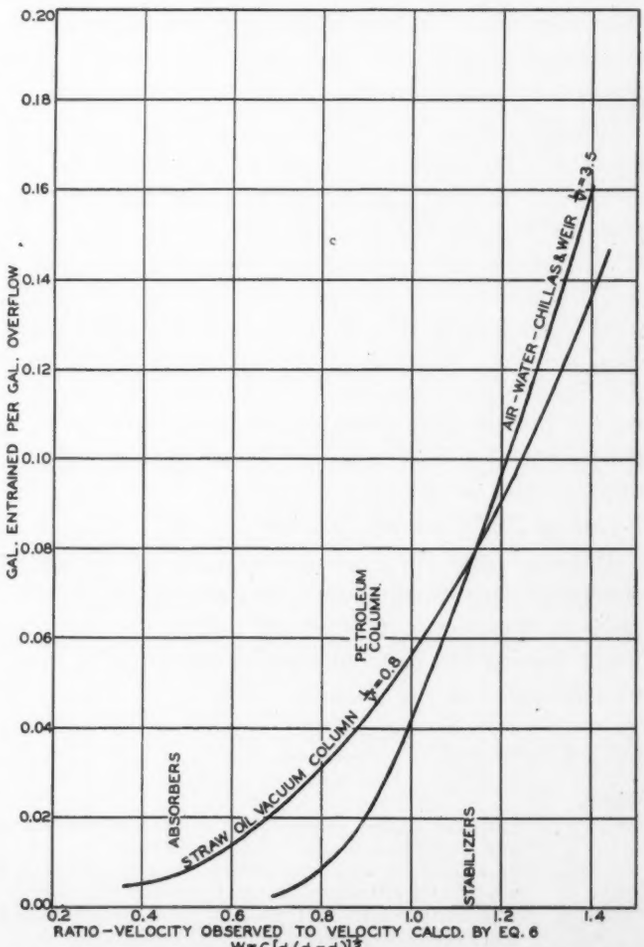



FIG. 4 EFFECT OF VAPOR VELOCITY ON QUANTITY OF ENTRAINMENT

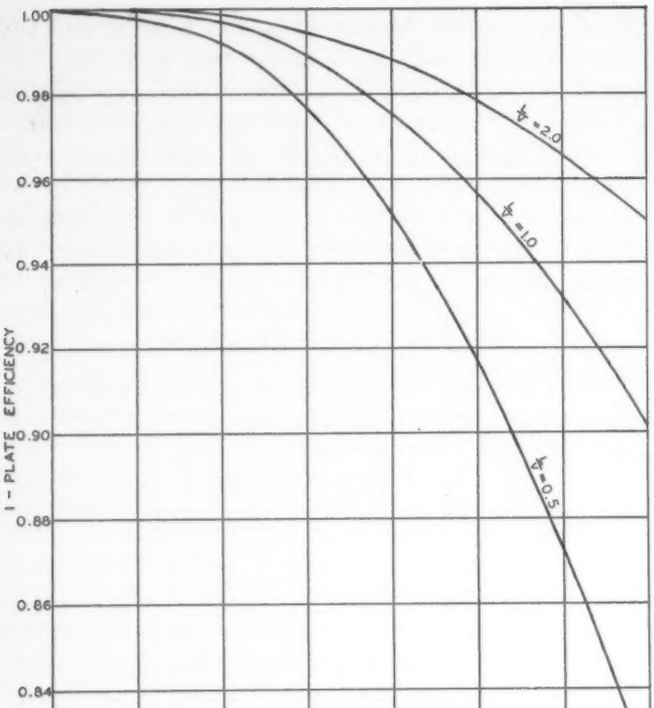



FIG. 5 EFFECT OF VAPOR VELOCITY ON EFFICIENCY OF TOP EQUILIBRIUM PLATE.

gressively diluted by the liquid overflowing from plate to plate.

*Effect on Quantity of Overflow.*

Wherever there is a sharp increase in the quantity of liquid entrained as may be caused by closer plate spacing or increase in mass velocity of the vapor (as below the point of introduction of a side reflux), the liquid load at and below this point of the column is increased in proportion to the net increase in the quantity of entrainment in addition to the increase in reflux. Such a sharp change in the quantity of entrainment may overload the normal liquid capacity of the column. For this reason the probable entrainment in various parts of the column should be considered in calculating the sizes of weirs and downspouts.

*Effect on Fractionating Efficiency.*

Defining plate efficiency as the ratio of the actual change in composition of the vapor passing through the plate to the change that would take place were the vapor leaving the plate in equilibrium with the liquid overflowing from the plate,

$$\text{Efficiency, } e = \frac{y_n - y_{n+1}}{Kx_n - y_{n+1}} \tag{7}$$

where

$y_n$ = mol fraction of same comp. in mixture of vapor and entrained liquid rising from plate

$y_{n+1}$ = mol fraction of a component in the mixture of vapor and entrained liquid from plate below

$K$ = equilibrium constant[5] i.e. the ratio between mol fraction in dry vapor and mol fraction in liquid under equilibrium conditions.

$x_n$ = mol fraction of same comp. in liquid overflowing from plate.

From a material balance around plate n assuming L and V to be constant

$$L(x_{n-1} - x_n) = V(y_n - y_{n+1}) \tag{8}$$

where

$L$ = total mols liquid overflowing from plate to plate

$V$ = total mols mixture of vapor and entrained liquid rising from plate to plate

$x_{n-1}$ = mol fraction of same comp. in liquid overflowing from plate above.

Combining Equations 7 and 8

$$e = \frac{y_n - y_{n+1}}{Kx_n - y_{n+1}} = \frac{L(x_{n-1} - x_n)}{V(Kx_n - y_{n+1})} \tag{9}$$

By definition

$$V = V' + E \tag{10}$$

where

$V'$ = total mols dry vapor rising from plate to plate

$E$ = total mols entrained liquid carried with dry vapor from plate to plate

Also, were there no entrainment

$$y_n' = fKx_n \tag{11}$$

where

$f$ = factor for deviation from equilibrium between dry vapor and liquid leaving plate.

Therefore

$$Vy_n = V'f\ Kx_n + Ex_n \tag{12}$$
$$= x_n[VKf - E(Kf - 1)]$$

and from Equations 8 and 12 (13)

$$Vy_{n+1} = x_n[VKf - E(Kf - 1)] - L(x_{n-1} - x_n)$$

Combining Equations 9 and 13

$$e = \frac{Lx_{n-1} - Lx_n}{VKx_n - x_n[VKf - E(Kf - 1)] + L(x_{n-1} - x_n)} \tag{14}$$

For plates above the feed plate

$$Lx_{n-1} = Vy_n - Dx_d$$
$$D = V - L$$

Where

$D$ = total mols of materials withdrawn from column above plate n

$x_d$ = mol fraction in composite overhead materials

$$Lx_{n-1} = x_n[VKf - E(Kf - 1)] - x_d(V - L)$$

and

$$e = \frac{VKf - E(Kf - 1) - \frac{x_d}{x_n}(V - L) - L}{VK - \frac{x_d}{x_n}(V - L) - L}$$

or

$$e = 1 - \frac{VK(1 - f) + E(Kf - 1)}{VK - \frac{x_d}{x_n}(V - L) - L} \tag{15}$$

A similar derivation for plates below the feed plate where

$$Lx_{n-1} = Vy_n + Bx_b$$
$$B = L - V$$

$B$ = total mols materials withdrawn from column below plate n

$x_b$ = mol fraction of same comp. in composite materials drawn below plate n

leads to the equation

$$e = 1 - \frac{VK(1 - f) + E(Kf - 1)}{VK - \frac{x_b}{x_n}(V - L) - L} \tag{16}$$

Thus the general equation for the effect of entrainment on plate efficiency becomes

$$e = 1 - \frac{K(1 - f) + \frac{E}{V}(Kf - 1)}{K - \frac{x_b}{x_n}\left(1 - \frac{L}{V}\right) - \frac{L}{V}} \tag{17}$$

where

$x_p$ = composite mol fraction in products withdrawn either (a) above plate n for plates above feed plate or (b) below plate n for plates below feed plate

Equation 17 may be simplified for special conditions, such as:

Equilibrium plate with total reflux, i.e.

$$f = 1 \text{ and } \frac{V}{L} = 1$$

$$e = 1 - \frac{E}{V} \tag{18}$$

Total reflux and no entrainment

$$e = 1 - \frac{K(1-f)}{K-1} \tag{19}$$

Top plate of a column where the reflux has the same composition as the overhead distillate, i.e. $x_{n-1} = y_n$

$$e = \frac{1 - \frac{E}{V}}{\frac{V}{L}\left(\frac{K - Kf}{Kf - 1}\right) + 1 - \frac{E}{V} + \frac{E}{L}} \tag{20}$$

And for a top plate which is an equilibrium plate, i.e. $f = 1$

$$e = \frac{1 - V}{1 - \frac{E}{V}\left(1 - \frac{V}{L}\right)} \tag{21}$$

As an illustration of the effect of vapor velocity and entrainment upon the efficiency of an equilibrium plate, $\frac{E}{V}$ ratios calculated from the straw oil curve of Figure 3 have been used in Equation 21 to construct Figure 5. Here the efficiency of a top equilibrium plate, at various $\frac{L}{V}$ ratios, is plotted against the actual mass velocity relative to the mass velocity obtained from Equation 6 and Figure 1.

*Allowable Quantity of Entrainment.*

The allowable quantity of entrainment may vary with the service of the column (whether absorber, stripper, fractionator, etc.) and may change from point to point in the column. Factors governing the permissible entrainment in gas absorbers and in flash chambers where impairment of color is a factor have been indicated.

If a bubble plate may be designed so that the entrainment ratio, $\frac{E}{V}$, is independent of $\frac{L}{V}$, the entrainment and mass velocity of the vapor permissible with a constant plate efficiency will vary directly with the ratio $\frac{L}{V}$, somewhat as indicated in Figure 5. That is, a greater mass velocity of the vapor would be permissible in columns or parts of columns where $\frac{L}{V}$ is relatively larger. Thus, greater mass velocity might be tolerated in the stripping sections of stabilizers or steam strippers than in the rectifying sections of the same columns. Similarly, the permissible mass velocity would be greater at the top of a topping column than at plates immediately above the feed plate; and the upper part of a topping column would be operated with greater mass velocity of the vapor than the upper or rectifying part of a column for stripping natural gasoline from absorbent oil.

On the other hand, there is evidence that the entrainment ratio, $\frac{E}{V}$, increases with increase in the $\frac{L}{V}$ ratio. Whether this effect is caused by increase in cap submergence or by greater velocity of the liquid (effects which could be minimized in mechanical design), or other factors is not yet clear.

For the present the limits indicated in Figures 3 and 4 may be used for the indicated services of columns of adequate mechanical design in practically all cases. Closer design may be accomplished if proper consideration is given to the effect of side stream withdrawals and intermediate reflux. The effect of the latter is to increase the entrainment below the point of addition to the column. But in many cases this increase in entrainment has little effect on the overhead products removed above the intermediate reflux if the downtakes are of ample size to handle the liquid overflow, because the excess entrainment caused by the intermediate reflux is eliminated usually about one plate above that which received the intermediate reflux. Problems of close design for such conditions require special consideration and good judgment as to the maximum quantity of entrainment that may be tolerated under different operating conditions and in various parts of the column.

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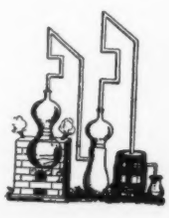


# Design Permits *Flexible Operation In Producing* Varied Products

GEORGE REID

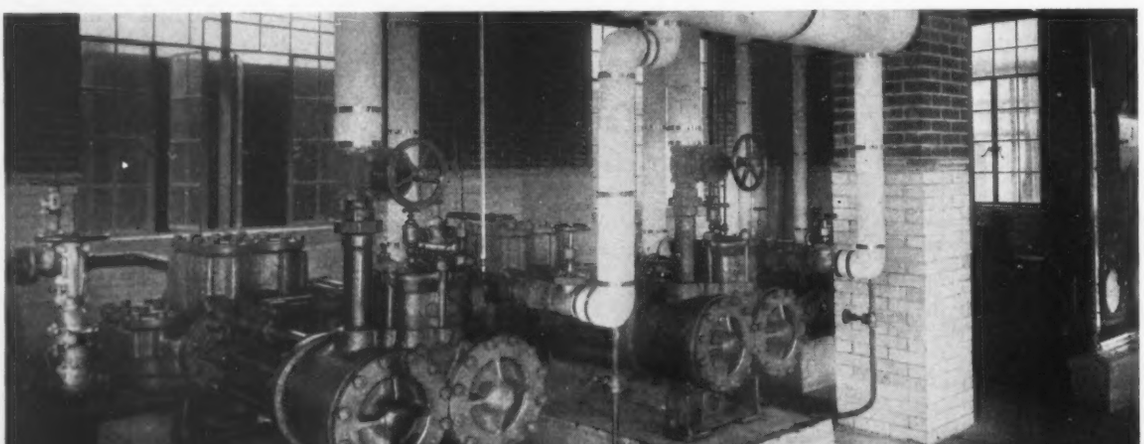
BRADFORD Oil Refining Company, Bradford, Pennsylvania, is operating a new tube still and fractionating column distillation system which incorporates some novel features of design and which secures products of unusual characteristics. The design permits of flexible operation practice both in the production of various overhead or light products and a wide range of heavier distillates, while securing close fractionation of all distillates under the various processing conditions.

Crude is charged to the unit through a series of exchangers to reecive a preheat of 300°F. before entering the tubes. Leaving the Dean Brothers steam-driven duplex charge pump the crude enters the "circulating reflux" exchanger, through which a side stream of naphtha used for temperature control at the top of the fractionating column is passing. This side stream is sufficiently hot to bring the crude oil temperature up to about 190°F. From this point the crude is conducted to a horizontal settling drum, where any salt, silt or other foreign matter is removed.

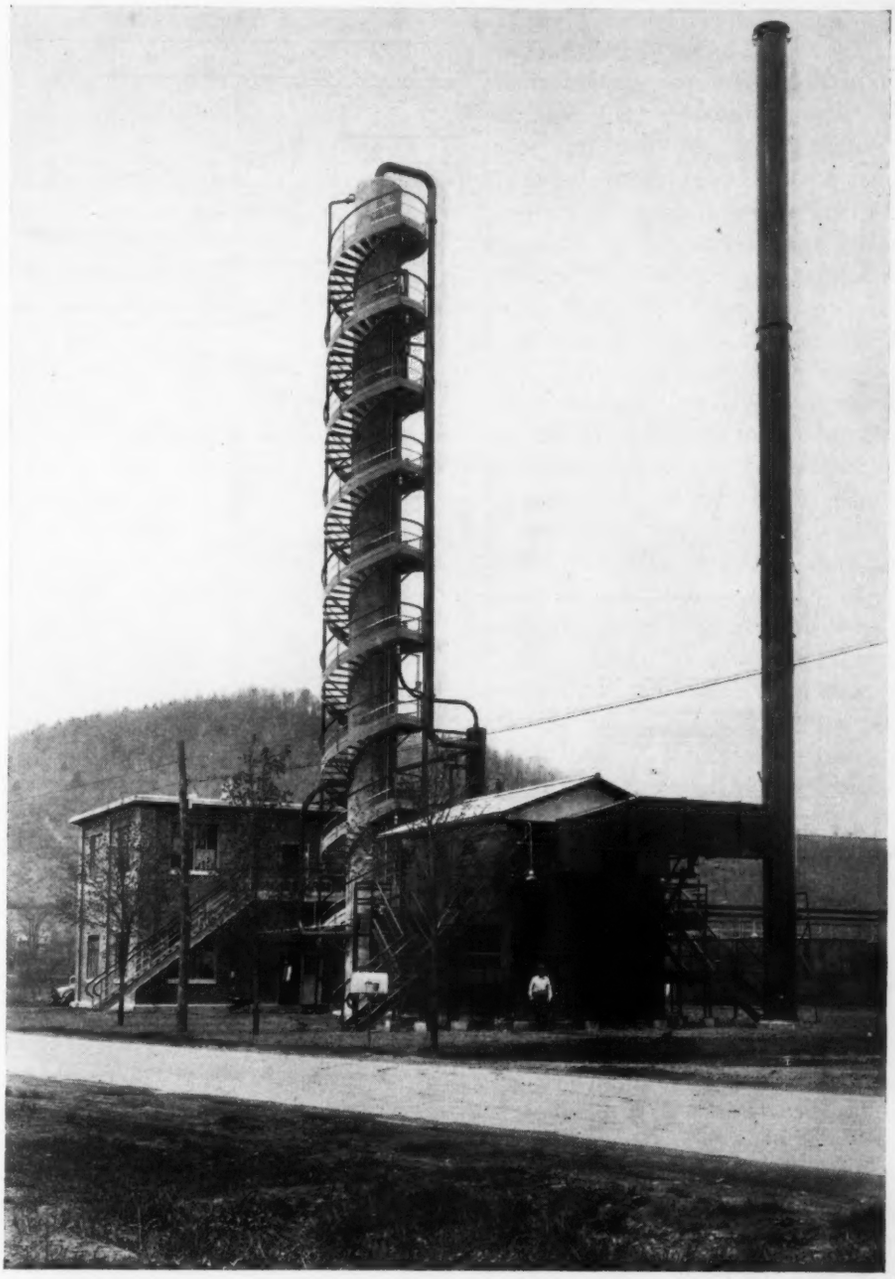
From the settling drum the oil passes to another exchanger through which the hot gas-oil side stream is passing, then to a similar exchanger where additional heat is recovered from the hot wax distillate side stream. All of the exchangers are Leader Industries design, which concern built the unit, and are equipped with Admiralty metal tubes.

Following flow through the system of tube-bundle exchangers the crude passes through a five-pass double pipe exchanger to enter the still tubes at 300°F. The charging pump pressure is 210 to 220 pounds; oil pressure at the tube still inlet is 190-200 pounds. A Masoneilan automatic recording control instrument governs the crude charging pump.

The tube still is provided with a bank of 68 tubes in the radiant section, eight front wall tubes, and 100 tubes in the convection bank, which is placed in the top of the still. A baffle insulated with Ascaloy is placed in the furnace, and the steam superheater tubes are of Ascaloy. The still tubes are small, being two inches in diameter, furnished by Globe Steel Tube Company and provided with Stockham return bends or headers. The use of such small tubes is in accord with the practice advocated by Dr. E. H. Leslie, of Leader Industries, Inc., and other technologists and is employed to secure high velocity of oil through the tubes, effecting a reduction of thickness of the stagnant film or skin of oil which lies next to the inner surface of a furnace tube. High velocities



***Interior of pump and control room, showing pumps used for charging crude to still.***



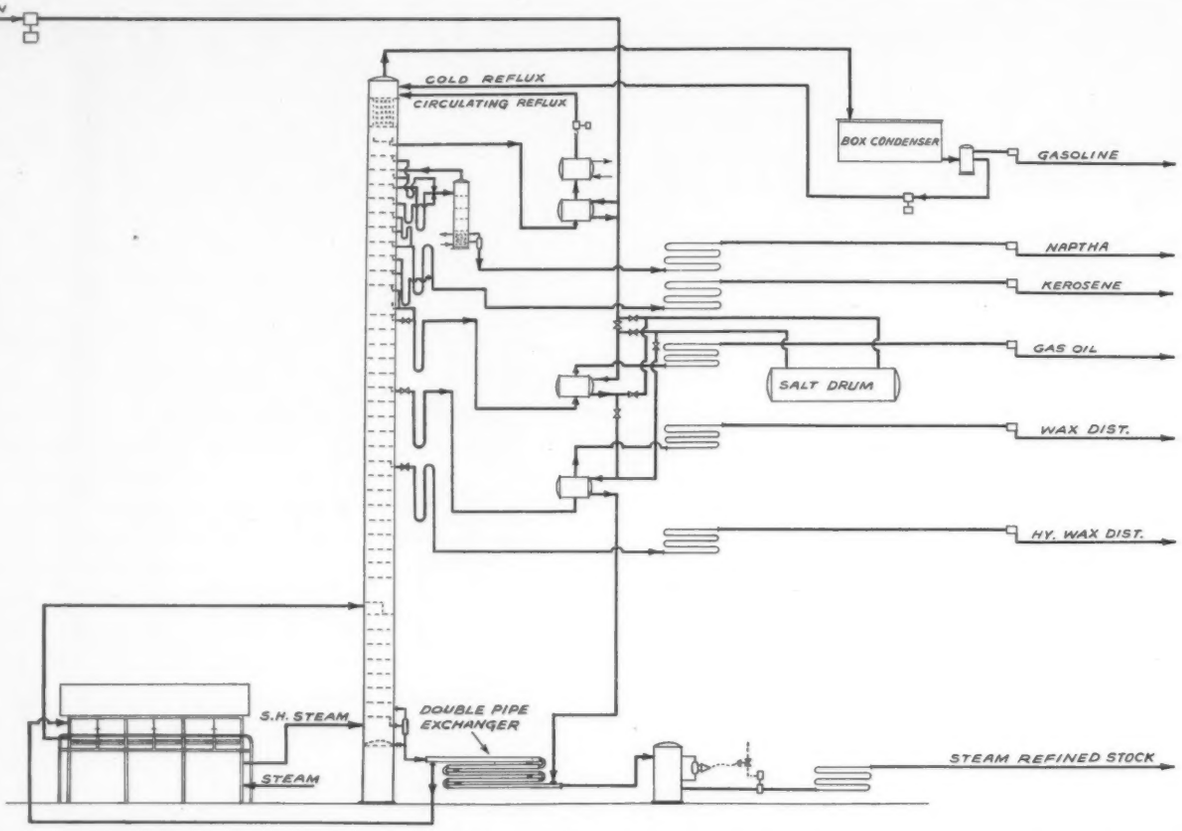
***Bradford Oil Refining Company's new distillation unit, at Bradford, Pennsylvania.***

are employed to secure a thin film so that practically no decomposition or cracking occurs and the transfer of heat to oil stream is accelerated. Thus the input of necessary heat into the oil is secured under mild conditions and at moderate temperatures.

The hot combustion gases sweep the convection section located at the top of the furnace and pass out through a breeching leading to the stack and placed at the top of the furnace and at the same end through which the still is fired. Fuel oil for still firing is circulated through a closed system by small Gardner Denver duplex pumps, entering the four National Air-oil burners at 65 pounds. The crude oil is heated to 675 to 680°F. and leaves the tubes at a pressure of 18 to 20 pounds.

The heated oil and vapors enter the side of the combination stripping and fractionating column, and at a point above seven specially designed bubble trays. The heavy stock descends through the stripper section of the tower and by the use of superheated steam is stripped of its lighter components, giving consistently higher Pensky-Martens flash points. The vapors pass upwards through the 31 bubble trays and a layer of vitreous tile in the fractionating section of the column, from which an overhead stream of gasoline and five side streams may be taken.

The superheated steam used in the stripper section of the column is comprised of exhaust steam from the pumps, or live steam from the power plant, or a mixture of the two, as need may be. A Masoneilan recording flow meter is used for measurement




***Flow chart of steam atmospheric topping and lube unit, Bradford Oil Refining Company, Bradford, Pennsylvania.***

and control of the superheated steam. This steam leaves the superheater coil in the furnace at 425°F. The steam lines are manifolded so that the quantity as well as the type (live steam at 75 pounds pressure, or superheated exhaust steam or mixtures of both) may be accurately controlled. Steam temperatures are recorded by a Masoneilan temperature recorder.

The accuracy of temperature control, steam control, and flow through the stripper section of the tower secures the high Pensky-Martens flash points on the steam refined stock or bright stocks. The stock, leaving the bottom of the column is conducted through a double pipe exchanger previously mentioned and accumulates in a nearby closed receiving tank. A Dean Brothers duplex pump, controlled by a Masoneilan liquid level controller on the receiving tank, removes the steam refined stock to storage while relatively hot as it leaves the exchangers, and from which storage it is immediately taken for further processing. This consists of dilution with naphtha, chilling, centrifuging, distillation for removal of the naphtha, and contact filtration for color, all in the conventional manner. Piping is manifolded so that the stock may be passed through cast iron coils in the cooling box for cooling if necessary.

Following the flow of the vapors upwards through the column, the first or lower side stream removed is a pressable wax distillate, which, because of the crystalline characteristics of the wax, and the consequent easy pressability, and because of its large yield of high quality neutral oil, commands as substantial premium when sold to other refiners. It is not processed at the Bradford plant. The column, however, is provided with side-draw equipment for the removal of two wax distillate streams, a heavy and a light fraction, for processing separately and subsequently blending back to given specifications, which adds much to the flexibility of the system. The yield of viscous neutral of 180 seconds viscosity at 100°F., is reported as comparatively high. It has a Number 4 N. P. A. color before filtering.

Gas oil is removed from the next higher side-draw-off from the column, and kerosene from the next higher draw-off point. The gas oil stream as it flows through the look box in the receiving house appears almost water white. When sold as fuel oil it commands a premium for domestic or special industrial fuel purposes because the efficient fractionation has stripped it of heavy ends and sticky constituents which tend to plug small orifices or to clog burner tips. This fuel oil is used to fire the furnace at the Bradford plant.

The kerosene side stream passes through a small stripper column where the light ends are removed by flashing with steam. Since the operation of the new

still began kerosene treating costs have been reduced 30 percent through reduction of acid and caustic requirements to secure standard specifications. The usual production runs 45/46 gravity, 370 I.B.P. and 530 E.P. Other grades or specifications may be produced as the need arises.

Both the gas oil and kerosene streams pass through exchangers as previously mentioned, giving up part of their heat to the incoming crude. From the exchangers they pass through cast iron cooling coils in the large cooling box and through the receiving house to storage.

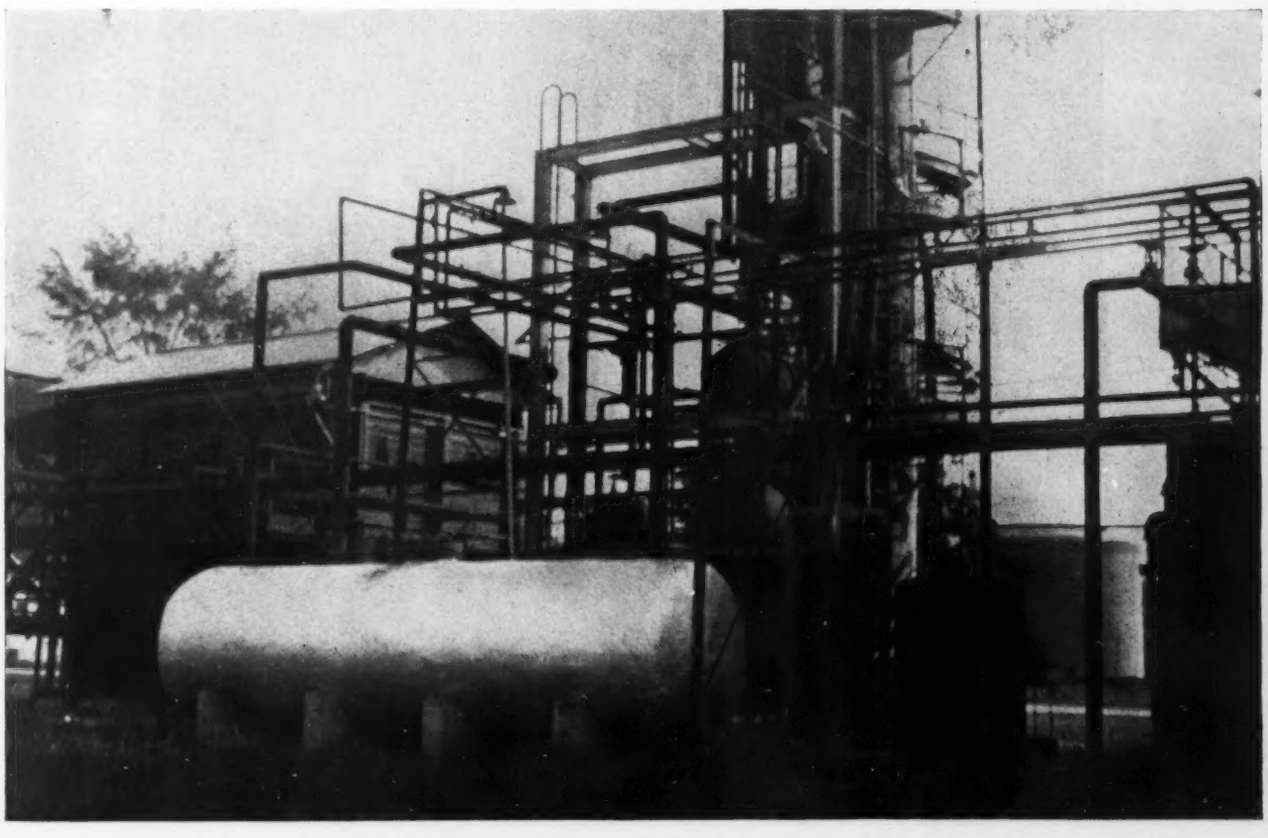
The next higher side stream is naphtha. The specifications of this stream may be varied to suit the needs of the plant. It is possible to remove directly from the column, solvents or paint makers naphtha, without refractionation, except, possibly, for a small side stripping column for control of initial boiling point. A typical naphtha produced for refinery use as solution for the centrifuging process is around 50 gravity, with a 310 I.B.P. and 400 E.P.

The last or upper-most side stream represents an innovation in distillation system design in as much as it is strictly a reflux medium and is returned to the tower for temperature control purposes. This side stream of circulating naphtha is removed through a heat exchanger where its temperature of 205 to 220°F. is used for preheating the incoming crude prior to its entry into the settling drum. Leaving this exchanger the reflux material passes through a second exchanger where it is cooled with water to about 80 to 120° F. This system eliminates the use of a vapor to oil heat exchanger.

The reflux or circulating naphtha is circulated by means of a Dean Brothers duplex pump. A second pump of the same type handles light gasoline from the receiving drum and discharges into the same line as the pump handling the circulating reflux; and the blended reflux passes to the top of the tower for trimming. Control of these pumps and rate of refluxing is secured by a Masoneilan recording controller, and the tower top temperature is held at 220°F. for the production of light gasoline. This product, of course, is varied in its specifications and the conditions of control are changed or modified, to meet various requirements. The circulating reflux constitutes about 85 percent of the reflux material necessary to control the tower temperature, and the remaining 15 percent is made up of gasoline as produced by the system.

The over-head gasoline vapors are condensed in a wrought iron pipe coil placed in a large condenser box, from where it flows to a receiving tank, which acts also as a water separator and as the point of suction for the reflux pump. The vessel is located inside of the receiving house, thus being protected from freezing weather—since the room is heated for the comfort of the operators.

For recording temperatures from various parts of the system a Brown recording potentiometer is em-



***Salt settling drum in the foreground. Exchanger system and piping in center.***

**TABLE 1**
**Wax Distillate**

| | New Unit | Old Shell Stills |
|---|---|---|
| Viscosity, Saybolt Universal, @ 100°F. | 85 | 88 |
| A.P.I. Gravity— | 33.8 | 34.5 |
| Open Cup Flash °F. | 333 | 225 |
| Open Cup Fire, °F. | 390 | 340 |
| Pour. °F. | 70 | 75 |
| Color, N.P.A. | 1½-2 | 4-4½ |

**TABLE 2**
**Steam Refined Stocks**

| | New Unit | Old Shell Stills |
|---|---|---|
| Viscosity, Saybolt Universal, @ 210°F. | 158 | 157 |
| A.P.I. Gravity | 26.0 | 25.7 |
| Open Cup Flash, °F. | 555 | 550 |
| Open Cup Fire, °F. | 630 | 625 |
| Pensky-Martens Flash, °F. | 545 | 485 |
| Carbon Residue | *2.35—2.45 | 2.85—2.95 |

*Bright stock from this steam refined stock has carbon residue of 1.38 as compared to 1.48 in the bright stock produced from the shell still steam refined stock, both filter to same color.

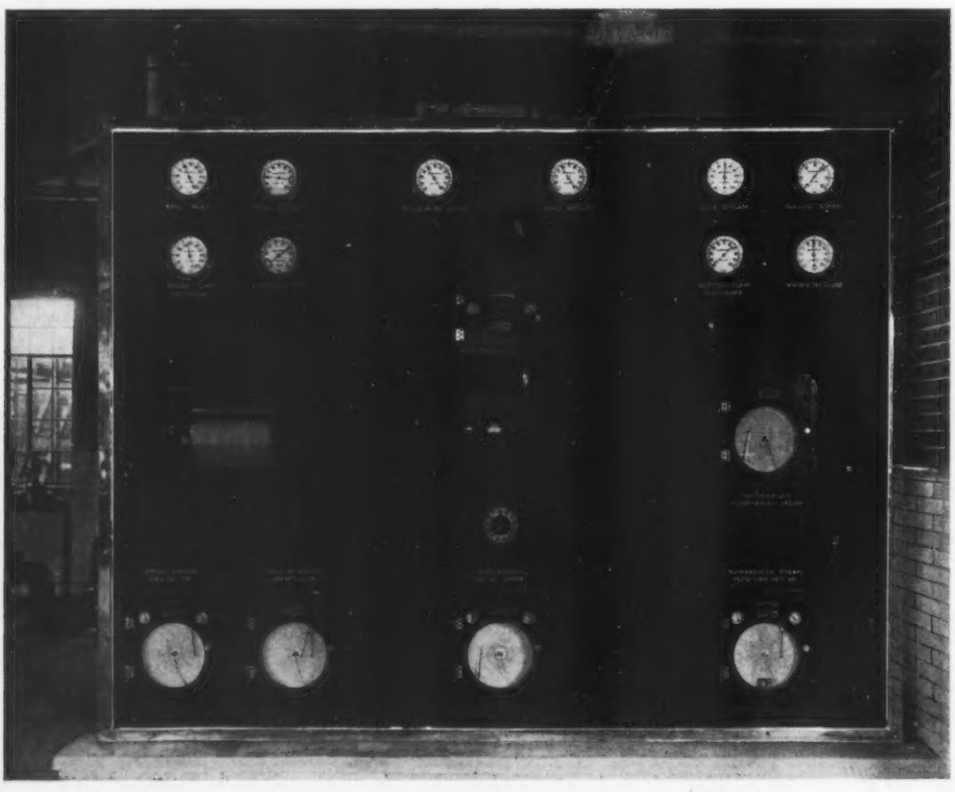
ployed. A Brown indicating potentiometer gives readings duplicating those of the recording instrument and several additional points, especially in the furnace, with a total of 12 points of temperature measurement.

The characteristics of cylinder stocks and bright stocks prepared by this system are said to be an unusually low Conradson carbon test, which runs around 2.4 percent on the steam refined stock and about 1.35 to 1.40 percent on the finished bright stock; the high flash point as measured by the Pensky-Martens closed cup, which runs within 10°F. of the flash point as taken by the open cup method; and a low pour point for a given viscosity.

The unit is designed to process around 1500 barrels of crude daily and when the oil is heated to 670°F. to enter the tower, about 20 percent of the charge is taken off as steam refined stock. It is thought that in addition to the elimination of cracking or decomposition of the oil due to the high velocity and mild conditions encountered in the still, use of the salt settling drum contributes much toward securing the low carbon residue of the finished steam refined and bright stocks. It is thought that lacking this treatment of settling, the salt water and silt tends not only to influence the deposition of carbon-forming constituents in the stocks, but evidence seems to point to the salt acting as a catalyst in the formation of carbon in the Conradson test. In addition, the salt settler has been effective in avoiding corrosion in the fractionating system.

The fractionating column is encircled from the top to base with a spiral steel stairway (the tower is 101 feet high), and this stairway was erected at substantially little additional cost. It lends accessability to any part of the tower, giving easy approach to any of the bubble trays or any part of the stripping section.

We are indebted to Mr. John Andrews General Superintendent for Bradford Oil Refining Company, for his cooperation in preparation of this description of the new distillation system.



***Control board, showing various controls employed in the operation of the distillation system.***

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# SCIENCE AND TECHNOLOGY

*Abstracts prepared in co-operation with the*

**REFINER AND NATURAL GASOLINE MANUFACTURER**

*by*

**THE LESLIE LABORATORIES**

**Traver Road, Ann Arbor, Mich.**

*under the supervision of*

**DR. E. H. LESLIE and DR. H. B. COATS**

*The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.*

*Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.*

## Fundamental Physical Data

**The Specific Heat of Oils.** M. LOUIS and M. ROLLIN. *Chimie & Industrie Special No.* (June, 1933) pp. 559-61.

A simple apparatus and procedure for the measurement of the specific heat of oils is described. It is claimed that the difficulties ordinarily encountered in the usual types of apparatus because of the low conductivity and high viscosity of oils are overcome. A definite weight of oil is heated for a definite time by means of an electric current. The increase in temperature is noted. Three oils from the same Alsatian crude were studied, and it was found that the specific heat increased with the decrease of density, and that the specific heat for any oil was a linear function of temperature.

**Low Temperature Specific Heats. I. An Improved Calorimeter for Use from 14 to 300°K. The Heat Capacity and Entropy of Naphthalene.** J. C. SOUTHARD and F. G. BRICKWEDDE. *Jour. Am. Chem. Soc.* **55** (1933), pp. 4378-84.

An improved adiabatic calorimeter for the measurement of the specific heats of liquids and solids between 14 and 300°K has been constructed. It can be used with a precision of 0.1% and is suited to the study of slow transition and several changes. The molal heat capacity of naphthalene was determined between 14° and 300°K, and the entropy and free energy of formation at 298.16°K were calculated.

**The Vapor Pressures of Propane and Propylene.** A. W. FRANCIS and G. W. ROBBINS. *Jour. Am. Chem. Soc.* **55** (1933) pp. 4337-42.

Data on the vapor pressure of propane and propylene as published in the literature are compared. The vapor pressures of these hydrocarbons were determined in the same apparatus for the first time above 0°C. The determinations cover temperature ranges of 27-64° for propane and 29-46° C. for propylene. The all glass apparatus used is described.

**The Thermal Conductivity of Oils.** LOUIS and CARRETTE, *Chimie & Industrie Special No.* (June 1933), pp. 556-8.

A new apparatus for the measurement of thermal conductivity of oils is based on Fourier's hypothesis. Heat is applied to the upper surface of a layer of oil floating on a layer of water. The temperature is taken by means of delicate thermocouples at 2 levels in the oil and 2 levels in the water after thermal equilibrium was obtained.

**The Knock Rating of 1-Heptine.** A. R. BOWEN, A. W. NASH and F. H. GARNER. *Nature* **132** (1933), pp. 410-11.

The knock rating of 1-heptine was determined by using the hydrocarbon in a 20% by volume blend with a standard fuel. The engine jacket temperature was 100°C. The blending octane number was found to be 79.5 Comparison of the knock rating of 1-heptine with that of representative 7-carbon-atom hydrocarbons of other series shows that the triple bond is more effective than the double bond in increasing the anti-knock rating, although the difference between a triple and double-bond compound is not as great as that between a double bond compound and a saturated compound.

**The Relation Between Constitution and Anti-Knock Value of Hydrocarbons III.** FRITZ HOFMANN, KURT BERLIN and A. W. SCHMIDT. *Brennstoff-Chem.* **14** (1933), pp. 326-8.

The anti-knock values for additional hydrocarbons and their polymers have been determined. Cyclohexene and butadiene have a much higher anti-knock value than their dimers. Anti-knock values for a number of compounds are shown graphically. Octane numbers were determined for the following hydrocarbons: butadiene 83; dibutadiene 60; di-cyclohexene 53; cyclohexadiene 79; an ethylene polymer of b.p. 140-210°C. 50; an ethylene polymer, b.p. 210-265°C. 47; tetrahydronaphthalene 65; decahydronaphthalene 50; ethyl alcohol 83; methylcyclopentane 59.

## Chemical Composition and Reactions

**Chemical Nature of the Gum Forming Constituents in Gasoline.** D. T. FLOOD, J. W. HEADKY and G. EDGAR. *Ind. Eng. Chem.* **25** (1933), pp. 1234-39.

The instability of cracked gasoline manifested in the development of objectionable quantities of gum on storage and in loss of anti-knock value is a matter of importance. It is now fairly well agreed that it is the gum actually present in gasoline at the time of its use that gives trouble from clogged fuel induction system and stuck in-let valve, that the tendency of a gasoline to form gum in storage is best indicated by some form of oxidation test, that gum formation is usually, if not invariably associated with oxidation, that gum formation can be inhibited by the addition of various anti-oxidants, that gasoline may lose anti-knock value on storage apparently by formation of oxygenated compounds acting as knock-inducers or by natural removal through gum formation of hydrocarbons high in anti-knock value, and that the anti-knock value may be partially or wholly restored by certain refinery treatments. The paper deals with a study of the individual gum-forming hydrocarbons. These were added in varying amounts to straight-run, paraffinic gasoline and the solutions subjected to the usual tests for gum stability, as well as to storage tests. The largest quantities of gum were developed in those solutions containing aliphatic or cyclic diolefins or mono-olefins attached to a benzene ring. In some instances, however, solutions containing high concentrations of aliphatic mono-olefins also formed appreciable quantities of gum The effectiveness of inhibitors was demonstrated and their action shown to be a prolonging of the induction period without apparently affecting the rate of oxygen absorption once the induction period is finished. No correlation was found between stability in storage and the length of the induction period as measured by the oxygen bomb. Nevertheless, a study of the complete oxygen bomb pressure curve may give valuable information as to the behavior of the gasoline in storage.

**Application of Raman Spectra to the Identification of Hydrocarbons in Motor Spirits.** A. ANDANT. *Chimie & Industrie Special No.* (June, 1933), pp. 480-91.

The Raman spectra of n-$C_6H_{14}$, n-$C_8H_{18}$, $C_{10}H_{22}$, $C_{11}H_{24}$, $C_{12}H_{26}$, cyclohexane, methylcyclohexane, m-dimethylcyclohexane, p-dimethylcyclohexane, cyclohexene, $C_6H_6$, $C_7H_8$, o-$C_8H_{10}$, p-$C_8H_{10}$, mesitylene, EtPh, PrPh, BuPh, AmPh, $C_6H_4Et_2$, $C_6H_3Et_3$, $C_6H_2Et_4$ are given and discussed from the standpoint of using these spectra in identifying hydrocarbons in solutions. In general the Raman spectra do not permit the direct identification of all hydrocarbons con-

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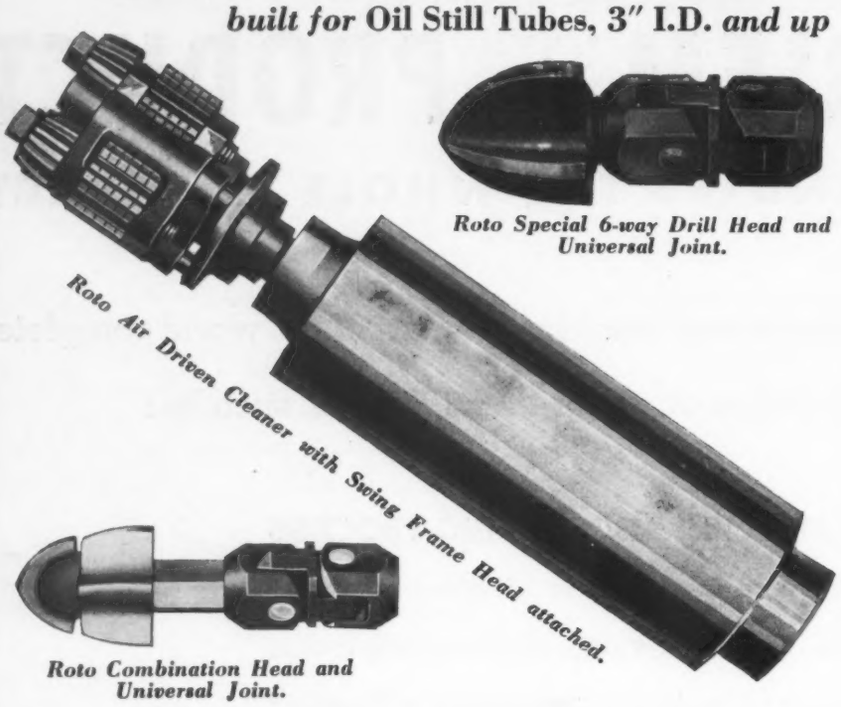

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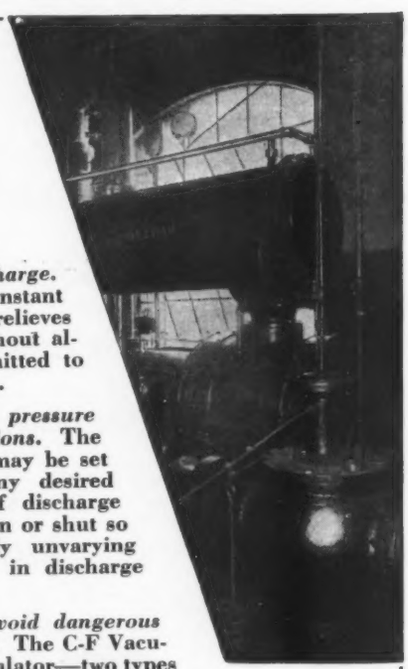

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tained in gasoline for the reason that hydrocarbons of the same group have similar spectra. However, the spectra unquestionably reveal chemical radical present, and in conjunction with the determination of the infra-red absorption spectra furnish information as to the individual components. The equipment and the technique for the determination of Raman spectra are described in detail.

**The Kinetics of the Thermal Decomposition of Tetraethyl Lead.** J. A. LEERMAKERS. *Jour. Am. Chem. Soc.* 55 (1933), p. 4508.

Previous studies of this subject are reviewed briefly. The kinetics of the decomposition were studied at 235, 260 and 275°C. The reaction was found to be mono-molecular in character and between 96 and 97% homogeneous. Ethyl radicals were found to react very little, if at all, with hydrogen at 275°C.

## Manufacture: Processes and Plant

**A Theoretical Comparison of Petroleum Distillation Systems.** P. MEYER. *Jour. Inst. Pet. Tech.* 19 (1933), pp. 819-34.

The author notes that many types of plants are used for the distillation of petroleum. In order to compare different systems and plants it would be desirable to have a correlative index embodying the main variables, such as number of plates, reflux ratio, type of apparatus and nature of material distilled. The distillation systems covered are: flash vaporization, continuous column distillation, and batch distillation. From a mathematical study of published data the author concludes that a numerical expression for the degree of fractionation is possible, that selection of the economic compromise between reflux ratio and number of plates can be facilitated, the more plates the column has the higher the reflux ratio necessary to make full use of the plates, at high reflux ratio for the same number of plates batch distillation is sharper cutting than continuous, but at commercially practicable reflux ratios continuous distillation shows a marked advantage over batch, continuous distillation cannot be accurately simulated by batch distillation.

**Cracking Process (for Oils).** E. BERL and W. DIENST. *Petroleum* 29 (1933) No. 32, pp. 1-4.

Gas oil was cracked in the liquid phase at 400°C. and 18 atmospheres pressure, and with reaction times of 70, 90, and 310 minutes. The yield of gasoline was 2.2, 5.9, and 8.5% for the three times. Corresponding yields at 425°C., 24 atmospheres, and the same times, were 10.2, 25.4, and 32.6%, respectively. The gasoline obtained consisted of 15-20% unsaturated hydrocarbons, 13-20% of aromatics, 0-8% naphthenes, and 58-62% paraffins. The aromatics were thought to be formed by the dehydrogenation of napthenes.

**Measurement of True Gas Temperatures.** S. UCHIDA. *J. Fuel Soc. Japan* 12 (1933), pp. 97-98.

A high-velocity thermocouple is used for the measurement of true gas temperatures. The blackness and diameter of the couples should be small, and the ratio of the temperature of the inner wall of the suction pipe to the true gas temperatures should be nearly unity. The min-

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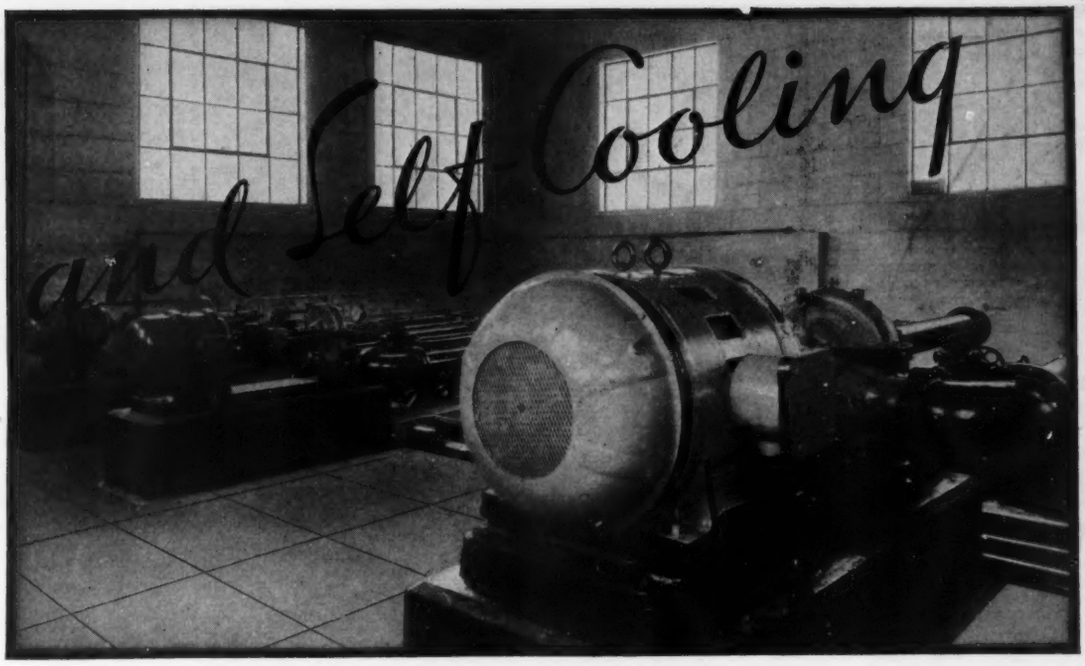

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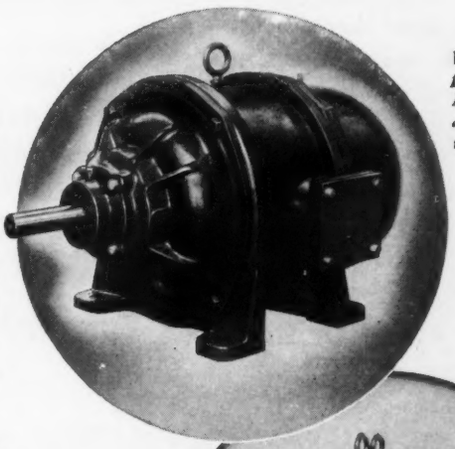

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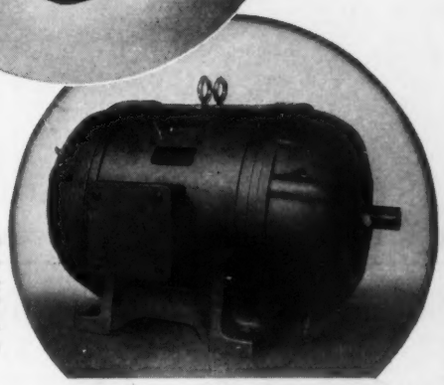

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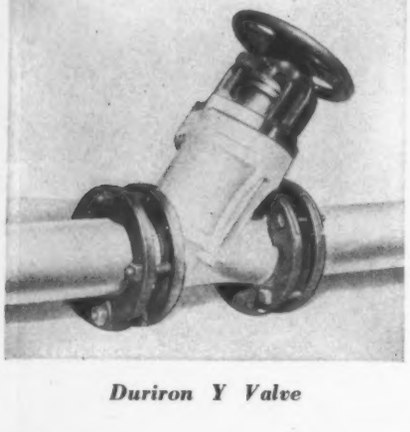

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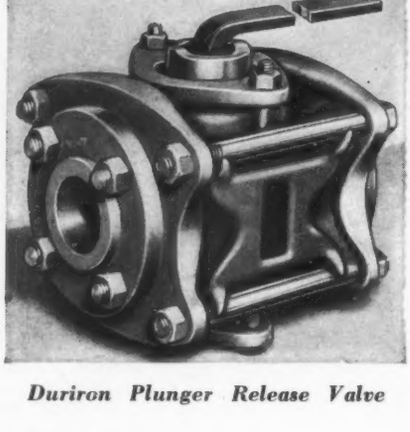

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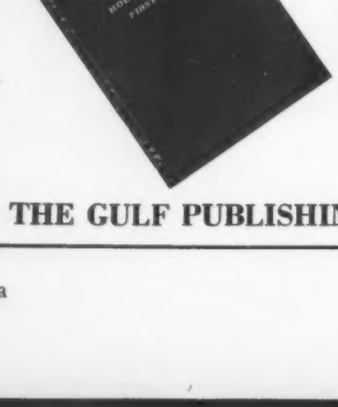


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imum gas velocities required under two different conditions are given.

**Measurement of Tube Wall Temperatures in Heat Transfer Experiments.** G. M. HEBHARD and W. L. BADGER. *Ind. Eng. Chem. Anal. Ed.* **5** (1933), pp. 359-62.

Determination of the temperatures of tube walls is an important part of experimental work on heat transfer coefficient. The authors describe a method of using thermocouples for the measurement of tube wall temperatures. Details are given as well as data to support the authors' contentions as to the value of their method.

**New Form of Insulation for the Introduction of Electrical Connections Into High Pressure Vessels.**. A. J. WELBERGEN. *J. Sci. Instr.* **10** (1933), p. 247.

A satisfactory method for making an insulated joint to withstand high pressures such as 3000 atmospheres is described. The joint comprises a conical sleeve of Pyrex glass which is melted into a conical hole in a plug of chromium steel. The temperature required is about 900°C. The connection is made through the glass plug. The entire assembly is heated to white heat and slowly cooled.

**Accurate Temperature Measurement in Oil Tanks.** R. FUSSTEIG. *Erdol u. Teer* **9** (1933), pp. 401-402.

The importance of the accurate measurement of temperature in determining the weight of oil in tanks is stressed. This is particularly true in the case of tanks heated by steam coils. It has been found that the variation in temperature is in a vertical direction, laterial differences were found small. The temperature is a maximum at the height of the steam coils, being less at the bottom and about half way up the tank and increasing near the top, finally decreasing somewhat at the surface. Methods of measuring temperature are described and a method of graphical integration for the determination of steam temperature is given.

**Foam Fire-Fighting Methods; Past, Present and Future.** HENRY S. SIMONIS. *Munic. Eng. San. Record* **92** (1933), p. 389.

Chemical and mechanical foam are compared. The A solution of chemical foam is water containing about 13% aluminum sulfate; the B solution contains approximately 8% sodium bicarbonate and a stabilizer such as saponin, licorice or Turkey-red oil. The author believes that most of the chemicals are wasted in creating carbon dioxide and are themselves of little fire extinguishing value. To make 800 gallons of foam requires 100 pounds of powder and 100 gallons of water. In making mechanical foam, on the other hand, 2 pounds of saponin solutions gives 1000 gallons of foam. The saving in cost is 90%. The product is more stable and is less dangerous to the fabric of the hose. Operating details are given.

## Products: Properties and Utilization

**Slope of the Viscosity-Temperature Function as an Important Criterion of the Value of a Lubricant.** H. UMSTATTER. *Petroleum* **29**, No. 31 (1933), pp. 1-3.

The author discusses the applicability of the

formula log n = A—B log T, where n = kinematic viscosity in centistokes, T=abs. temperature, and A and B are constants, to lubricating oils in studying approximately 100 oils. The values of B varied from 2.6 to 8.8 and can be determined with a probable error of 0.02. The author considers that the values of B are a suitable measure of the lubricating values of the oil. The relation of B to friction losses are discussed, as well as the effect of a temperature gradient within the oil layer on the friction losses.

**Lubricating Properties of Greases from Petroleum Oils.** F. H. RHODES and H. D. ALLEN. *Ind. Eng. Chem.* **25** (1933), pp. 1275-80.

In lubrication by soda base greases the soap plays an important part in the formation of the lubricating film. Also, the glycerol present aids in stabilizing the structure of the grease, reduces the change in consistency on heating or working, increases the lubricating value, eliminates the increase in the coefficient of static friction on heating, and reduces the susceptibility to moisture. Greases containing two or three times as much glycerol as results from the saponification of the fat contained in the grease are better lubricants than those that contain merely the glycerine equivalent to the soap. However, larger quantities of glycerol again decrease the lubricating value. An apparatus is described for the measurements of the coefficient of static friction.

**Determination of Paraffin in Raw Oils and Their Derivatives.** A. CHMELEVSKY. *Rev. o Petrolifere* (1932) pp. 982-4; *Chem. Zentr. II* (1932, pp. 2574-5.

Holde's method is modified by conducting the distillation in a cathodic vacuum. Decomposition is avoided and a pure paraffin fraction obtained that can be accurately assayed by the method of Holde. In examining two oils by the methods of Holde the author and Scholler found the following percentages of paraffin: 6.6, 7.8 and 8.0; and 2.8, 3.5 and 3.3. The paraffin separated by the first two methods was white; that separated by Scholler's method was yellow. The filter used was Jena glass crucible with fitted glas bottom as proposed by Verdier. By the author's method crystalline and amorphous waxes can be separated. Those in high boiling oil fractions can be analyzed exactly.

**Ozone, Knock-Inducer Extraordinary.** D. B. BROOKS. *Jour. Inst. Pet. Tech.* **19** (1933), pp. 835-44.

It was discovered that when the air going to an engine was treated with a Cottrell precipitation apparatus the fuel detonated severely. Various causes were considered, but it was concluded that the effect was the result of the presence of ozone. The author concludes that the effect of ozone and tetraethyl lead, while opposite, are of the same order of magnitude. The use of ozone in studies of detonation should prove useful. Different quantities of ozone are required to counteract equal improvement in anti-knock value of a fuel as obtained by the use of different knock inhibitors. In the concentration used ozone was without measureable effect on power, economy, or optimum spark advance.

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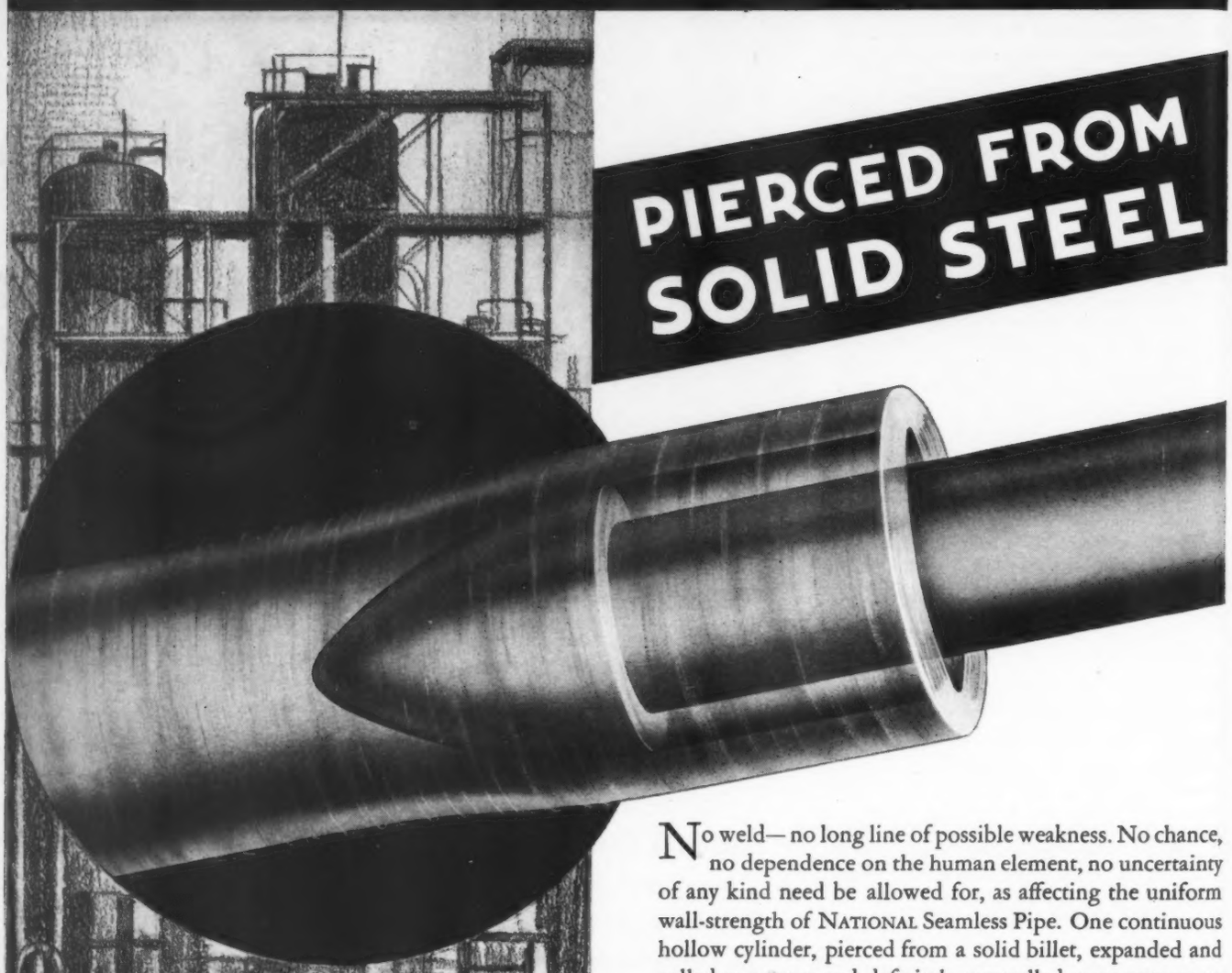

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# THE MONTH IN REVIEW

## 1934-Spring Conventions

THE spring months of 1934 will see a number of conventions of oil men and meetings of engineering and chemical societies.

During March the American Society for Testing Materials will hold Group Meetings of the A.S.T.M. Committees, and the 1934 Regional Meetings from March 5 to 9, inclusive, at the Ardman Park Hotel, Washington, D. C. The eighty-seventh meeting of the American Chemical Society will be held at St. Petersburg, Florida, during the week of March 25. The Division of Petroleum Chemistry of the A.C.S. has decided not to convene at the eighty-seventh meeting in Florida, but will hold a joint meeting with the Twelfth Midwest Regional Meeting, at Kansas City, Missouri, early in May.

During April the annual meeting of Western Petroleum Refiners Association will be held, but dates have not yet been set for this convention. In Cleveland, April 19 and 20 the National Petroleum Association will hold its semi-annual convention.

The Oil Equipment and Engineering Exposition will be held in Houston, April 16 to 21, inclusive.

At Kansas City, Missouri, May 3 to 5, the American Chemical Society will hold its Mid-west regional meeting at the Muehlbach Hotel, which is a joint meeting with the Division of Petroleum Chemistry.

May 9, 10 and 11, at the New Hotel Tulsa, Tulsa, Oklahoma, the Natural Gasoline Association of America will hold its thirteenth annual convention. Following this, and from May 12 to 19, inclusive, the International Petroleum Exposition will be held at exposition grounds in Tulsa. During the exposition the Petroleum Division of the American Society of Mechanical Engineers will hold its annual meeting, May 14 to 17. The semi-annual meetings of the three divisions of the American Petroleum Institute will be held in Pittsburgh, May 22 to 24. The next meeting of the American Institute of Chemical Engineers will be held some time in May, in New York, at the Waldorf-Astoria hotel, but definite dates have not been set.

During June, the American Society for Testing Materials will hold its annual meeting at Chalfonte-Haddon Hall, Atlantic City, from June 25 to 29, inclusive.

Pennsylvania Grade Crude Oil Association, June 28 and 29 will have its convention at State College, Pennsylvania.

## Petroleum Chemists Join Midwest A.C.S. Meet

THE Division of Petroleum Chemistry of the American Chemical Society has decided not to meet at St. Petersburg, Florida, but instead will join the Mid-west Regional Meeting which will be held at Kansas City, Missouri, May 3, 4 and 5. Communications regarding papers for this occasion should be addressed to Group Secretary H. M. Steininger, Standard Oil Company (Indiana), Sugar Creek, Missouri, or in care of the Kansas City office, 700 Baltimore Avenue, Kansas City.

## Committees Appointed for Institute Refining Division

APPOINTMENT of R. E. Wilson, Standard Oil Company (Indiana), Chicago, as chairman of the Central Committee on Refinery Technology for 1934 has been announced by Vice President Howard Bennette, of the American Petroleum Institute, as chairman of the General Committee of the Division of Refining. Dr. R. P. Anderson, of the institute staff, is secretary.

Chairman Wilson has appointed the following officers of committees working with the central group in 1934:

Committee on Accident Prevention in Refineries: C. W. Smith, Standard Oil Company (Indiana), Chicago, chairman; H. N. Blakeslee, American Petroleum Institute, Dallas, secretary. Committee on Corrosion of Refinery Equipment: Walter Samans, The Atlantic Refining Company, Philadelphia, chairman; D. V. Stroop, American Petroleum Institute, New York, secretary. Committee on Disposal of Refinery Wastes; John S. Hess, Sinclair Refining Company, New York, chairman; Mr. Stroop, secretary.

Committee on Fire Prevention in Refineries: C. E. Townsend, Sun Oil Company, Philadelphia, chairman; Mr. Stroop, secretary. Committee on Motor Fuel Research: Dr. Anderson, chairman. Committee on Standardization of Refinery Equipment: Arthur E. Pew, Jr., Sun Oil Company, Philadelphia, chairman; Dr. Anderson, secretary. Committee on Testing Methods and Specifications: K. G. Mackenzie, The Texas Company, New York, chairman; Dr. Anderson, secretary.

## Natural Gasoline Meet, May 9, 10 and 11

THE Thirteenth Annual Convention of the Natural Gasoline Association of America has been fixed for May 9, 10 and 11, at Tulsa, with headquarters in the New Tulsa Hotel. Tentative dates previously announced were changed on account of the decision of the International Petroleum Exposition to hold the Exposition in Tulsa during the week of May 12 to 19, inclusive, because it was felt that it was undesirable to attempt to hold association business sessions during the week of the exposition. Ray E. Miller, secretary of the association in his announcement calls attention to the fact that Tulsa hotels will be crowded during the exposition and that reservations should be made early by those expecting to be in attendance.

## A. S. T. M. Meetings

THE American Society for Testing Materials has announced that the 1934 A.S.T.M. Regional Meeting will be held at Wardman Park Hotel, Washington, D. C., March 7. At the same place, and on March 5 to 9, inclusive, the 1934 group meetings of the A.S.T.M. Committees will be held.

The annual meeting of the society will be held at Atlantic City, Chalfonte-Haddon Hall, June 25 to 29, inclusive.

The technical feature of the regional meet at Washington will be a Symposium on Outdoor Weathering of Metals and Metallic Coatings, sponsored jointly by A.S.T.M. Committee A-5 on Corrosion of Iron and Steel, and Committee B-3 on Corrosion of Non-ferrous metals and alloys.

## First-Aid Training By A. P. I. Authorized

UNDER authorization from the members of the accident prevention committees of the three divisions of the American Petroleum Institute—production, refining, and marketing—plans are being worked out for the issuance of certificates of first-aid training to employes in the petroleum industry by the Institute. General provisions of the plan contemplate that the United States Bureau of Mines First Aid Manual shall be used as a

basis for the course of training and that a committee of three headed by a former Bureau of Mines instructor shall outline a general course of training. It is contemplated also that the safety engineer of the Institute's Department of Accident Prevention shall have general supervision over issuance of certificates, and he shall be responsible for aiding smaller companies, which are not able to employ a full-time safety director, to obtain instructors or to arrange joint classes to accommodate employes of several companies.

In joint sessions of the accident prevention committees in Chicago recently, H. N. Blakeslee, director of the department, explained that because the Bureau of Mines never has been able to supply all of the instructors needed in the oil industry, it has encouraged companies to permit the Bureau to train company instructors. Examinations of company trained men have been conducted by Bureau representatives, and Bureau of Mines certificates issued to those who qualify.

Since September, 1931, when the first A. P. I. Accident Prevention Manual was published, six have been issued, including: Cleaning Petroleum Storage Tanks; Safe Driving of Automobiles; Gas and Electric Cutting and Welding; Organization for Accident Prevention; Safe Operation of Service Stations, and Precautions in Well Pulling.


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**The Refiner—*First in its Field***


## Index to A. S. T. M. Standards Issued

THE Index to A. S. T. M. Standards and Tentative Standards, issued annually in December by the American Society for Testing Materials is now being distributed. The Index gives under appropriate key words, the titles of all of the society's standards, together with page references to the A.-S.T.M. publications in which they may be found. Each specification and test method is indexed under the principal subject it covers. Purchasing agents, specification writers, testing engineers and many others find the Index of considerable assistance, not only in locating a particular specification or method of test, but also in determining whether or not there is an A.S.T.-M. standard on a specific subject.

Copies of the Index are furnished upon request, without charge. The new address of the American Society for Testing Materials is Atlantic Building, 260 South Broad Street, Philadelphia.

## Cracking Development Meet Elects Permanent Officers

THE Sub-Committee on Research, of the Cracking Development Conference, held its mid-winter meeting, December 13 and 14, at the Hotel Commodore, in New York. Standard Oil Development Company, representing Standard Oil Company of New Jersey interests, having come into the conference since the last meeting, at Whiting, Indiana, in June, was among the companies who participated in the technical program. Prior to this addition of Standard Oil Development Company, the Cracking Development Conference included The Texas Company, Standard Oil Company (Indiana), Gasoline Products Company, and The M. W. Kellogg Company. At the recent meeting, permanent officers were elected.

During the past several years, the Cracking Development Conference has met semi-annually to review technical development and to consider methods of processing applicable to the cracking field. The object of the conference is to correlate experimental and plant development work, in pyrolytic crack-

ing, which is carried on in the laboratories and refineries of the participating companies. It serves as a clearing house for improvements in processing methods and acts as a committee on standards used in the design of equipment. Designs and improvements pertain to processes such as Cross, de-Florez, Holmes-Manley, and Tube and Tank, and to combination units which are licensed to the industry under the scope of cracking patent rights of Gasoline Products Company. Improvements favorably passed by the conference, are incorporated in new designs, and in the remodeling of present cracking equipment.

The conference is organized according to three principal functions, namely, cracking plant operations, engineering and design, and research. At the recent meeting in New York, it was realized that the work of the Cracking Development Conference, and of the Sub-Committee on Research, was becoming so extensive in scope, and so large in volume, that a permanent form of organization should be adopted. Previous meetings had been held at Los Angeles, Whiting, Port Arthur, and New York, and under this arrangement whoever acted locally as chairman to arrange for a given meeting, served then as chairman of the conference. According to the new arrangement, a permanent chairman, vice chairman, and a chairman of the subcommittee on research, will be responsible for handling the meetings, regardless of where they are held. The place of meeting will be varied as heretofore.

Wm. F. Moore of Gasoline Products Company, who has presided at the New York meetings, was elected the permanent chairman. John T. Ward of The M. W. Kellogg Company, was elected vice chairman. Mr. Ward also becomes the permanent chairman of the sub-committee on research. The headquarters of the conference will be at the offices of Process Management Company at 405 Lexington Avenue, New York City. It is believed that the continuity of function, obtainable through having permanent officers, will prove effective in coordinating the progress, from meeting to meeting, in the subjects discussed.

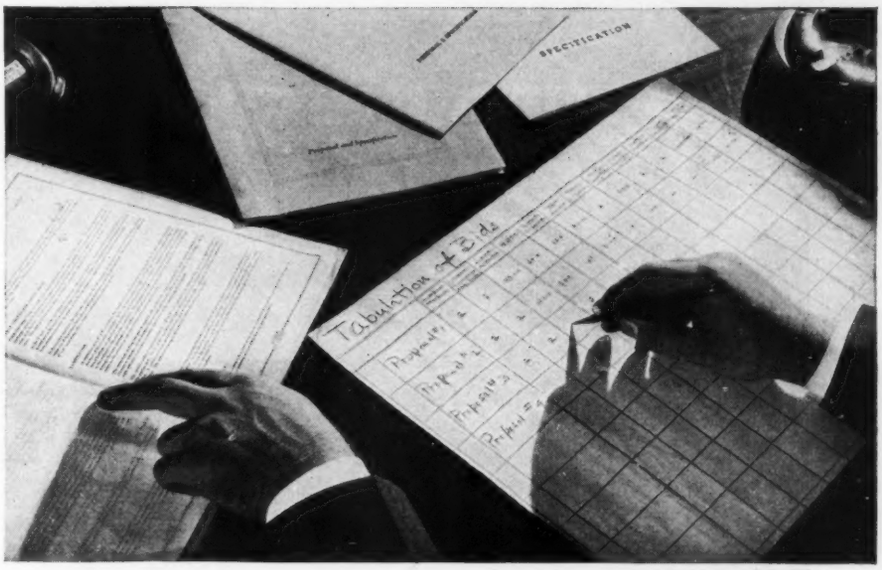
The next meeting of the general conference has been scheduled, tentatively, for April, at Port Arthur, Texas. The sub-committee on research will probably meet there, simultaneously, but will have its own separate sessions just prior to the convening of the group as a whole.

J. W. GLASS, superintendent, White Eagle Oil Corporation refinery at Casper, Wyoming, is reported recovering from severe injuries sustained in an automobile accident near Evansville, Wyoming.

H. J. ROSE, senior fellow, Mellon Institute of Industrial Research, Pittsburgh, has been elected chairman of the Gas and Fuel Division of the American Chemical Society for the year 1933-1934. Dr. Rose has been a member of the Mellon Institute research staff for the past 16 years.

F. W. ELEY, chief chemist, Northwest Stellarene Company, Coutts, Alberta, Canada, is reported recovering following an accident which resulted in the fracture of his right leg.

G. H. BARROW, formerly with Grayburg Refining Company, San Antonio, Texas, is now superintendent for La-Pren Refining Company, Kilgore, East Texas field. A. S. Robertson, also formerly with the Grayburg concern is now sales manager for the La-Pren Refining Company.


# ALL SPECIFICATIONS THE SAME

## . . . but are they?

**You can specify details up to a certain point. You can tabulate and compare quantities, capacities and sizes . . . and prove to yourself that all specifications are equal. But can you tabulate "beneath-the-surface" workmanship and materials? Can you tabulate years of experience and intensive research? Can you tabulate lower maintenance expense, longer life, greater dependability, and overall plant efficiency? Can you tabulate a factory trained field organization in which you can concentrate full responsibility for sound engineering, correct installation and proper functioning of the completed plant in the years to come? If you can . . . you will arrive at the true measure of value.**

NRA

**YORK ICE MACHINERY CORPORATION • YORK • PENNSYLVANIA**

REFRIGERATION • ABSORPTION & COMPRESSION
COMPLETE BRIGHT STOCK PLANT DESIGN

DR. S. W. FERRIS, refining technologist, The Atlantic Refining Company, who has devoted most of his time during the past few years to solvent extraction technology, spoke to the Franklin Institute, Philadelphia, December 14, on solvent refining of lubricating oils. Members of the institute represent every phase of chemistry and engineering in the vicinity of Philadelphia. Dr. Ferris and his associates developed the nitrobenzene process and during the past few years have investigated practically every solvent which has been considered by the industry.

DR. OTTO V. MARTIN, 41, chief chemist and consulting engineer for The Texaco Salt Products Company (subsidiary of The Texas Corporation) died at a Tulsa hospital January 2, after protracted illness from heart and intestinal ailments. Dr. Martin developed the processes by which oil well brine is used as a cooling medium for condenser coils at The Texas Company, West Tulsa refinery, and the heat extracted from the coils is used to evaporate the water and leave free salts, from which it is possible to produce 22 different products. Dr. Martin received his doctor's degree at the University of Chicago in 1921. During the war he was assigned to the chemical warfare division in Washington working in connection with the preparation of poison gases.

C. M. JOHNSON, consulting engineer, Houston, and formerly with Crown Central Petroleum Corporation, is now with Danciger Oil & Refining Company and located in Tulsa.

A. L. CLAYDEN, Research Engineer, Sun Oil Company, has been nominated as vice president of the Fuels and Lubricants Division, Society of Automotive Engineers.

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G-E EXPLOSION-PROOF REFINERY MOTORS

Assure Safety, Economy, Dependability

HERE are some of the reasons why G-E totally enclosed, fan-cooled motors for Class I, Group D, locations are safe, economical, and able to stay longer on the job:

Strong, reënforced housings safely withstand internal explosions

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Cartridge-type ball bearings sealed in grease for protection against dust and moisture

Motor cooled by air, fan-forced through ample passageways

Underwriters' Laboratories label; motors are tested and listed for Class I, Group D, locations as defined by the National Electric Code

Write for publication GEA-1716 on explosion-proof motors and control. Address the nearest G-E office, or General Electric, Dept. 6B-201, Schenectady, N. Y.

020-6

GENERAL ELECTRIC

R. B. HIGH

R. B. HIGH, formerly manager of the Houston refinery for Shell Petroleum Corporation, has been promoted to manager of manufacture for the company and is now located at the company's St. Louis headquarters.

DR. ARTHUR DEHON LITTLE, head of the widely known consulting firm of Arthur D. Little, Inc., chemists, engineers, on the occasion of his seventieth birthday, December 15, was presented by his staff with a specially bound and inscribed volume of the Morse Collection of Japanese Potteries. Presentation was made by Roger C. Griffin, director of tests, and a member of the board of directors of Arthur D. Little, Inc. Mr. Griffin is a son of Mr. Roger B. Griffin, who was Dr. Little's original partner when the organization was formed by Griffin & Little in 1886.

B. W. VINSON

B. W. VINSON of B. W. Vinson Company, Inc., Tulsa, was elected president of the Natural Gasoline Supply Men's Association by the board of directors December 22, 1933. Other officials are J. H. Satterwhite, Westcott & Greis, Inc., Tulsa, vice president; M. H. Kotzebue, Tulsa Boiler & Machinery Company, Tulsa, treasurer; and Roberta Hughes Coman, assistant treasurer.

The report of the treasurer for 1933 indicated a cash balance for the end of the year of $1,804.19 with all bills paid. With the collection of all dues the association will complete a year with a withdrawal from surplus of only $3.78. Since only $75 remained to be collected this withdrawal is anticipated. A withdrawal of $200 was anticipated for the year.

The board decided to continue annual dues at $50 and to continue the arrangement with the trade papers for the exchange of membership for advertising space. W. D. Moorer was named chairman of the advertising committee with the privilege of selecting the remaining personnel.

The new president will appoint all committees for the year.

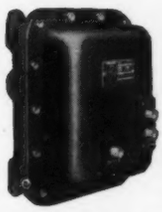
J. H SATTERWHITE

## Home-Made Walkways For Servicing Engines

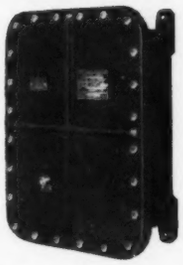
KANOTEX REFINING COMPANY, Arkansas City, Kansas, operates a small power room in conjunction with the vapor recovery and pressure distillate stabilizer unit, and to assist the engineers and oilers employed in this department, have placed semi-permanent walk-ways beside the engines so that dirt and other foreign substances may not be scuffed off the


# Protect Your Employees,

## your plant, and production — use G-E explosion-proof control

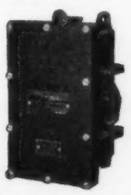


*CR7006, Size 1, magnetic switch, 7½ hp., 440 volts, 3 phase*



*CR7006, Size 2, magnetic switch, 25 hp., 440 volts, 3 phase*

*CR7006, Size 3, oil-immersed magnetic switch, 50 hp., 440 volts, 3 phase*



*CR1062-E3B motor starting switch, 7½ hp., 440 volts, 3 phase*

***Built to Underwriters' Laboratories Specifications***

The G-E explosion-proof control shown is built to the standards of, and is tested by, the Underwriters' Laboratories for Class I, Group D, hazardous gas locations.

***Will Withstand an Internal Explosion***

All of the control illustrated is built to the Underwriters' Laboratories specifications for the air-break type, with wide joints and ample strength to withstand an internal explosion and prevent any flame from escaping from the device.

***Oil-immersed Types for Corrosive Atmospheres and Outdoor Service***

The oil-immersed types, which are suitable for outdoor service, use oil to protect the contacts from corrosive atmospheres and to permit more compact construction.

***Includes Features of Standard Control***

G-E explosion-proof control incorporates the electrical features and advantages of G-E standard general-purpose control. All the magnetic- and manual-starting switches shown have thermal overload protection. The push-button stations are of strong construction, with ample clearances to give trouble-free service.

***New Publications Available***

Request copies of our recent publications on explosion-proof control, GEA-1588 and GEA-1716, from the nearest G-E sales office, or address General Electric, Dept. 6B-201, Schenectady, N. Y.

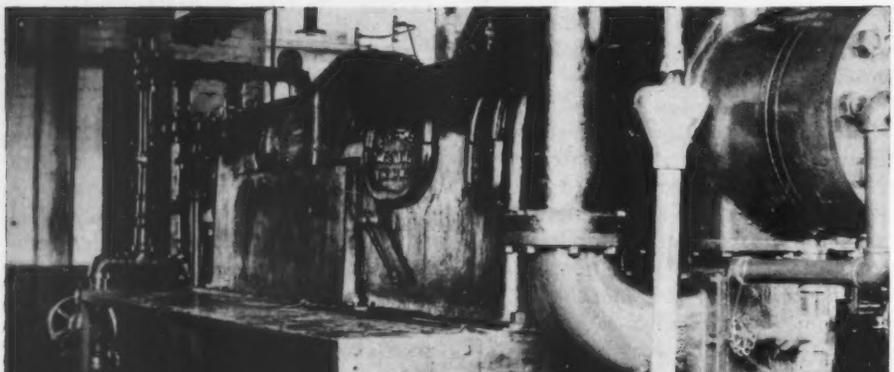
*CR1061-B1C motor-starting switch, ¾ hp., single phase*

*CR2941-E1 oil-immersed push-button station*

*CR2941-A1 push-button station*

080-3

GENERAL ELECTRIC



***Walks built for convenience of operators servicing engines in Kanotex Refining Co.'s vapor recovery engine room at Arkansas City.***

shoes into the oil channels of the bed-plates.

Surplus tank steel was utilized for the entire assembly. One piece long enough to reach from one end of the bed-plate to the other and about 14 inches wide was cut for the runway. Light angle iron was welded to the outer edge, completely around the piece of flat iron. Angle iron of the same weight was welded to two corners to serve as legs, long enough so that when the assembly was placed in position, the runway was flush with the top of the oil channel rim on the bed plate. Three straps of heavy iron were welded to the side intended to rest against the engine, curved in such manner that they rested upon the rim of the oil channel, with the end dipping down to prevent the assembled walk from slipping sidewise.

Steps were fabricated from the same material as the platform, conforming to the shape of the foundation block and the intake stool supporting the air line leading to the power cylinder. Two steps were made, welding the treads to the risers, and both to side plates cut to support them. The last riser in the step assembly rises to be flush with the upper side of the walk, and is bolted to the angle iron welded to that end.

When it becomes necessary to clean around the side of the engine where the walk is placed, it may be slipped to one side by simply lifting the assembly high enough that the straps supporting it on the engine side may slip from the rim of the bed plate. It may be placed in position again by moving it against the engine. The assemblies in this engine room have been in service for some time, and painted the same color as the engines, they harmonize with the lines of the compressors and prevent slipping when leaning over the engines as the operators service the machines.

## Efficient Wiping Cloth Washer

PROBABLY the operation of a steam box used in cleaning rags and overalls dates back to the first refinery or drilling well. Most anything was put up just so the steam was partly confined to the box in removing grease and stains incidental to operating the various pieces of equipment.

But to confine the washing operation to a more definite process, Gilmore-Dabney Gasoline Company in the Long Beach field, California, have installed a very efficient washer that not only conserves the washing powder used, but the steam and hot water as well. A section of an old tower, cut off with a torch was provided with welded ends making a "cheesebox" apparatus about 36 inches in diameter and about 24 inches deep. This was placed upon a welded stand in a concrete splash basin, and a hole was cut a little to one side of the top and the piece removed. Another sheet of steel large enough to cover the hole and provided with hinges, was fastened to the wash box so that a steam-tight door was provided. A hasp and staple was provided to lock the box during the washing period.

Three-inch lines were welded tangentially to the lower side, so the water and steam injected causes the rags to assume a whirling movement around the box. Two of these lines carry steam, and the one in the center furnishes hot water. When washing the rags and wiping cloths, some kind of washing compound is poured into the machine, the dirty cloths dumped in and the hot water valve opened. When sufficient water has been admitted to thoroughly dampen the bundle, steam is introduced through the two lines on either side of the water line. The operation is then carried out without attention until it becomes necessary to rinse the bundle of rags.

To prevent splashing of water and soap suds, a vent was cut on one side of the drum, a little above the center. A shield was provided to force the splash downward so that it can drain into the concrete vat and away with the rinse water.

## Horn Sounds When Power is Off

SUDDEN interruption of electric current driving essential motors may result in serious damage to certain units in refineries, especially if the break or failure of power is not noticed immediately. The damage is greater when motors are carrying the load of the hot oil pumps supplying the tubes in the high temperature furnace, or, driving water pumps which circulate cooling medium over gas engines or Diesels driving the charging units. To eliminate as much of the time factor

***Power Failure Alarm***

as possible when a sudden break in the delivery of current occurs, especially when there is nothing to warn the operators immediately, Marathon Oil Company has equipped the pump depended upon to furnish cooling water to the two 90 horsepower National Transit gas engines, with a positive horn warning signal.

Making an extended connection at the point on the upper side of the low pressure large volume centrifugal pump, this line crosses over and extends downward to a common two-inch diaphragm regulator valve set on a rigid foundation near the pump base. The counterweights attached to the arm of the valve are so placed that a 10-pound drop in pressure will permit the arm to fall against a stop. Between the weight and the body of the valve an ordinary knife blade switch is placed so that when the arm is lowered, contact is made with the wires leading to two automobile horns, one placed in the control room and the other outside the pump room building.

A common six-volt storage battery furnishes current for the horn.

## Portable Pipe Fitter's Work Bench

ONE of the larger gasoline manufacturers in the Signal Hill district of the Long Beach area has devised a simple pipe fitter's work bench, readily portable. and . easily. dis-assembled when it is found advisable to transport any considerable distance. It is construced by utilizing 1½-inch pipe from the supporting legs and any convenient lengths of two-by-twelves which may be selected from the lumber pile.

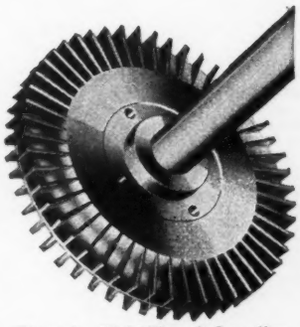
Four pieces of pipe form the supporting legs, each pair being connected at one end by welding a cross-piece of pipe, the same size of the legs. In doing this, the opposite ends are tilted towards each other at an angle to provide a stand which prevents side sway when assembled. Across this unfinished end are welded two other cross pieces, one at the extreme end and the other about 2½ inches further down, the distance being determined by the thickness of the boards available for a working surface. When both pair of legs have been finished, the two-by-twelves, or other dimension lumber, may be slipped through the slots provided by the two upper cross pieces, and when the spaces have been properly made, the bottom of the legs slant backwards providing a substantial bench. If the distance between the two upper cross pieces is too great, a slant greater than that needed for effectual bracing is provided, while on the other hand, if the space is so close that difficulty is found in slipping the boards through the slots, the supporting stands will be wobbly and not furnish the solidity needed when cutting and threading pipe.

The flexibility of this kind of a work bench is such that it may be used in the engine room, out in the open, in the stock room, or at any point around the plant where a work bench is needed. In places where a heavy semi-permanent bench is placed, the room it occupies is often needed more than the bench. If placed in the open, the men who work upon it are exposed. But with this portable bench in use, it may be readily moved to any point desired, and by providing planks of different lengths, the bench may be used in small buildings or in places where room is at a premium. When the need for the bench has passed, it may be readily dis-assembled, the planks returned to the lumber pile and the supporting legs stored in the stock room. The expense of fabricating the legs is nominal. Pipe may be found in the junk pile that will serve admirably for the legs, and the planks may be taken from scaffolding ordinarily used about the yard.


# 3 WEEKS for the JUDGE
# 3 MINUTES for YOU

**NOT so long ago, it took 3 week's time and almost 1,000 printed pages of technical testimony to convince a Court of Equity why Westco Turbine Pumps are DIFFERENT from all other pumps using centrifugal force.**

**With all due respect to His Honor, that much time and type are not needed to explain Westco's difference. We're sure you'll get the point from these two brief paragraphs:**



*Westco's Multi-Vaned Impeller. It does the "business".*

***In all other centrifugal pumps, a given particle of liquid leaving the Impeller Blade DOES NOT come back into contact with the Blade. The Impeller acts on it only ONCE.***

***In a WESTCO, the same particle of liquid is repeatedly engaged by the Impeller Blades. This re-energizing action produces pressures which in many cases are as much as 20 times greater than those which can be produced by centrifugals of the former type.***

***Westco users get the benefits of Multi-Stage performance while only paying for Single-Stage construction.***

### *Will Not Vapor Bind!*

**These modern, Refinery Pumps handle light, volatile gasoline, propane, etc. of 100° to 140° A.P.I. against pressures up to 300 lbs.—and they do it WITHOUT vapor binding.**

### *Automatically Adjust*

**Even if the operating pressure might fluctuate considerably, Westco automatically adjusts itself to such changes. A steady, non-pulsating flow is assured at all times. By increasing the efficiency of the towers, this characteristic makes Westco the ideal pump for feed and reflux duty on high pressure stabilizers. Our Refiner friends also like Westcos for Still Charging and for handling Hot Oil, Fuller's Earth, Chlorine Treating Solutions, Mineral Seal Oils, Naphtha, Brine, Water, etc.**

### *Get the Details*

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# WESTCO *TURBINE* PUMPS
HIGH PRESSURE - - - SINGLE STAGE

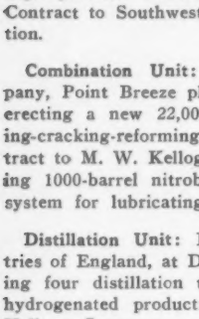
# PLANT ACTIVITIES

**Gasoline Plant:** Mohawk Oil Company, Mountain View field, southeast of Bakersfield, California, is erecting an absorption type gasoline plant and stabilizer unit including two high pressure boilers for steam generation. Contract to Southwestern Engineering Corporation.

**Combination Unit:** Atlantic Refining Company, Point Breeze plant, near Philadelphia, is erecting a new 22,000-barrel combination toping-cracking-reforming - stabilizing unit. Contract to M. W. Kellogg Company. Also installing 1000-barrel nitrobenzine solvent extraction system for lubricating oil manufacture.

**Distillation Unit:** Imperial Chemical Industries of England, at Dillingham, England, erecting four distillation units for fractionation of hydrogenated products. Contract to M. W. Kellogg Company.


Economy! "3-in-1" PULMOSAN Respirator



Buy one respirator and several parts. Interchanging parts gives protection for dusts, fumes, smoke, paint spray mists.

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PULMOSAN SAFETY EQUIPMENT CORP.
176 Johnson St. Brooklyn, N. Y.



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You Will Equip All of Your Boilers with the

CAMPBELL Feed Water Regulator

Ask for a list of prominent refineries in which this remarkable regulator is now functioning. No thermostats. No generators. No floats. No moving parts in the Regulating Element.

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ATLAS VALVE COMPANY
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Clip this coupon to your letterhead, check the items in which you are interested, mail, and we will gladly send prices and data. No obligation.

- ☐ The Campbell Boiler Feed Water Regulator
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- ☐ Float Valves
- ☐ Swing Joint Fittings
- ☐ Bronze Unions
- ☐ Thermostats
- ☐ Balanced Valves
- ☐ Control Valves


**Grease Plant:** American Lubricants, Inc., Buffalo, N. Y., doubling capacity of grease plant, including tankage, new boiler, grease kettles, pumps, and the like.

**Refinery:** E. Donald Marr has been granted permit to erect a 2500-barrel refinery on a 10-acre site at Avalon Boulevard and 223rd Street, Los Angeles, Harbor district. Frank A. Millif, formerly of Marine Refining Company, will be in charge.

**Refinery:** Creditul Minier, at Brazi, south of Ploesti, Roumania, to build modern refining plant, 1200 tons daily, and equipped with Dubbs cracking unit; reaction chamber contract to A. O. Smith Corporation. Steam power plant and electricity generating plant included. Edeleanu kerosene treating plant reported. To be completed in 1934.

**Gasoline Plant:** Paramount Natural Gasoline Corporation, subsidiary of Danciger Oil & Refining Company, is completing erection of a Tulsa Type well pressure gasoline plant in the Pledger field, Brazoria County, Texas. To operate at 800 pounds pressure.

**Gasoline Plant:** Smith Brothers Refining Company, McLean, Texas, erecting well pressure absorption gasoline plant in the Shamrock field, Section 28, Block 24, H. & G. N. Survey, Wheeler County, Texas Panhandle. Company organized by Vester Smith, T. J. Coffey and Porter Smith.

**Gasoline Plant:** Tall Pines Natural Gasoline Corporation, Tyler, Texas, completing erection of combination type gasoline plant, Kilgore section, East Texas field. Plant located on Luling Oil & Gas Company's W. P. Brightwell lease, R. E. Winn Survey, Rusk County. Colonel R. D. Gordon, formerly Eastland, Texas, is head of this company.

**Gasoline Plant:** Chief Refining Company, Gladewater, East Texas field, erecting small gasoline plant on site near its crude skimming plant. Capacity 3500 gallons. Owners propose doubling capacity soon.

**Alkali Plant:** The Mathieson Alkali Works, Inc., New York, has started work on a $7,000,000 industrial chemical plant, at Lake Charles, Louisiana. The company has purchased extensive salt rights in Cameron Parish, Louisiana. Plant to produce soda ash, caustic soda and other chemicals. Raw salt will be transported from the salt deposits to the plant through a pipe line. The company has also purchased 1600 acres in Calcasieu Parish. Plant is to be in operation by the end of 1934.

**Gasoline Plant:** Hanlon-Buchanan, Inc., Tulsa, announces plans for erection of natural gasoline plant east of Gladewater, East Texas field. Gas from 800 wells will be processed through plant to handle 8,000,000 cubic feet daily to produce 25,000 gallons of gasoline. The plant will be 100 percent owned by the company.

**Refinery:** Gold Standard Refining Company, under direction of B. F. Beaubier, is rebuilding the Kling-Del refinery erected some years ago near Wainwright, Alberta, Canada, to process crude from the Wainwright field.

**Compounding Plant:** Refiners Products Company, Bradford, Pennsylvania, planning establishment of a lubricating oil compounding plant, under direction of I. B. Morgan, formerly of Pennsylvania Petroleum Company.

**Repairs:** Owl Refining Company, Kilgore, East Texas field, has replaced equipment damaged early in December by fire.

**Recovery Plant:** Panhandle Refining Company, Wichita Falls, Texas, has let contract to Burrell-Mase Engineering Company, for erection of a combination vapor recovery and stabilization plant. Construction starting immediately.

**Dismantling:** Marathon Oil Company, Boynton, Oklahoma, refinery, erected in 1916, is being dismantled and sold as junk to Sonken-Balamba Corporation, Kansas City. Dismantling is being rushed so that the 180 acres of land comprising the plant site may be used for other purposes.

**Operating:** Sandy Refining Company, Big Sandy, Texas, began operating its 500-barrel skimming plant late in December. Formerly identified as Rainbow Refining Company, and later as Rex Refining Company. Organizers, V. O. E. Wright, C. B. Davis, L. Schnieder and J. T. Castleberry.

**Modernizing:** Pierce Oil Company, S. A., (owned by the Sinclair interests), is installing a new 6000-barrel topping plant, renewing transfer lines in the plant, adding tankage and making general improvements. Capacity upon completion of present work will be 15,000 barrels per day.

**License Agreement:** Lion Oil Refining Company, El Dorado, Arkansas, has recently entered into a license agreement with Gasoline Products Company, Inc., to cover a cracking installation of its own design. The new unit takes the place of the old Burton stills formerly operated.

**Gasoline Plant:** Sinclair Refining Company, reported planning erection of a 40,000-gallon natural gasoline plant, 15 compressor machines, in the East Texas field, to be located on the Hobart Key farm, Castleberry Survey, Gregg County.

**Refinery:** Economy Oils Ltd., Calgary, Alberta, Canada, is reported planning erection of a small refinery. E. F. Bowden is head of the company now in retail and wholesale distribution of petroleum products.

**Gasoline Plant:** Community Natural Gas Company, Muskegon, Michigan, is reported planning erection of a natural gasoline plant in the Central Michigan producing fields. J. P. McCloskey and Lee S. Miller head this concern. Headquarters, Muskegon.

**Cracking Unit:** Henry H. Cross Company, Smackover, Arkansas, has begun operating 1300-barrel "Ampco" type cracking unit.

**Gasoline Plant:** Otha H. Grimes, Tulsa, has started construction of a 5000-gallon natural gasoline plant in the Chippewa-Greendale field, Michigan. Robert Chisolm in charge of construction, headquarters, Mount Pleasant, Tulsa Type equipment being installed. Plan expansion later as field development progresses.

**Purchase:** Yale Oil Corporation of South Dakota, has purchased interest in refinery owned by Bales Oil Trust, located at Worland, Montana. It is reported that capacity will be increased to 500 barrels daily.

**Refinery:** Mid-Western Refining Company, Alma, Michigan, planning erection of new central Michigan refinery. B. J. Skinner, president. Plans include 10-mile pipe line from Porter Township pool to Alma.

# New Equipment for the Modern Plant

## Flow Controller

**C. J. TAGLIABUE MFG. COMPANY**

C. J. Tagliabue Manufacturing Company, Brooklyn, New York, announces that the Tag Magnetic Clutch Flow Controller, introduced in oil work nearly two years ago, is now being furnished with an advanced type air operated control mechanism known as the Tag Damplifier.

The manufacturer reports the success of the magnetic clutch construction for which the following advantages are claimed, corrosion-proof because internal parts are all stainless steel and immersed in mercury, freedom from leaking or binding because there is no stuffing box, manometer construction suitable for 2500 pounds working pressure.

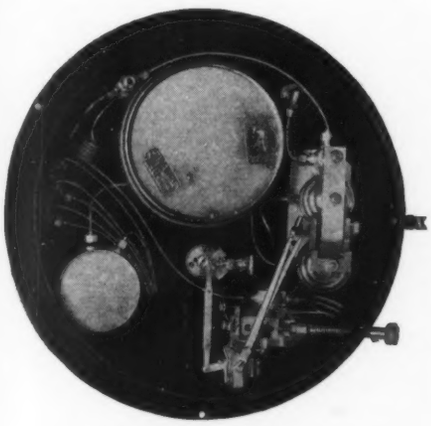
The Tag Damplifier Control Mechanism employes the principle of Damped Amplification. The combination of an inherently balanced primary or detector control system with a secondary amplifying control system makes possible realization of desirable characteristics of automatic control.

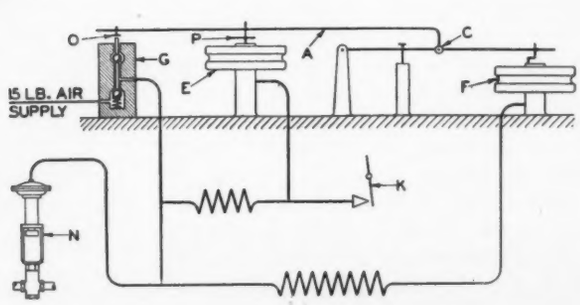
The Tag Damplifier will maintain the setting point precisely, even though this may require at times an almost closed diaphragm valve and at other times an almost wide open valve. Under all conditions throttling non-hunting regulation is provided. Smooth compass-line control is secured, and even when extraordinary upset conditions momentarily throw off the control, the Tag Damplifier brings it back right to the setting point without overswinging. The operation is as follows:

The primary pilot of the control system is the flapper valve which is positioned by the recording pen. Assume a condition when the pen is directly at the desired rate of flow which is being correctly maintained by the diaphragm valve. A 15-pound air supply is maintained to the ball air valve G. (See sketch). Something now occurs causing a tendency toward a decreased flow which instantly moves the pen downward. To maintain the flow at the setting point now requires a greater valve opening; that is, less air on the diaphragm top of the valve. The pen moves the flapper K toward the nozzle decreasing the air escape and increasing the pressure in detector capsule E which brings lever A upward causing ball valve G to decrease air pressure to the diaphragm valve. The decreasing tendency is partially arrested by this same decreasing air pressure reacting on the detector capsule E so that only a small diaphragm valve change takes place. Simultaneously, the Damped Amplification action of amplifier capsule F is taking place. This very slowly deflates capsule F lowering fulcrum C of main lever A and moving point O upward (P being the fulcrum) thus slowly amplifying the initial change in position of ball valve G.

All this time the gradually decreasing air pressure on diaphragm valve N has been opening the diaphragm valve thus increasing the flow and gradually moving the recorder pen and flapper K back to its original position.

Equilibrium of the control system is thus restored only when the recorder pen is exactly at the setting point.



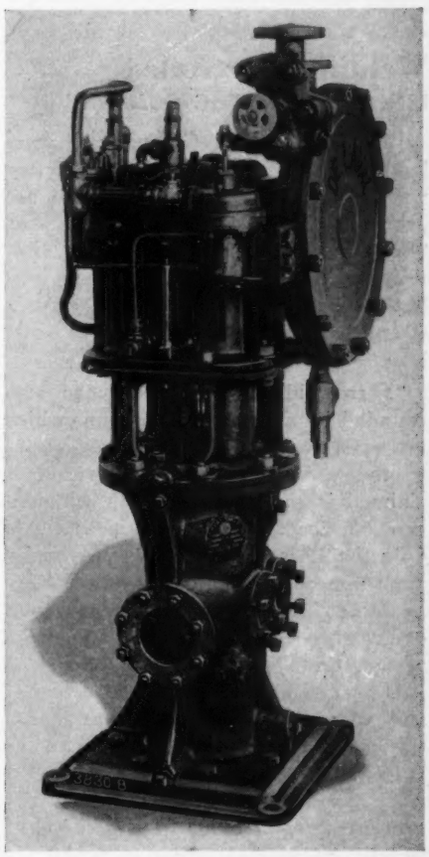



***Tag Magnetic Clutch Flow Controller.***

## Rotary Pump

**DE LAVAL STEAM TURBINE CO.**

De Laval Steam Turbine Company, Trenton, New Jersey, furnished rotary displacement pumps for handling fuel oil to burners or oil to lubrication systems, which operate with no valves, no shock or pulsation, run at relatively high speed, and in the type shown in the illustration, have only one shaft packing and no packing under high pressure.



***DeLaval-IMO Fuel Oil Pump***

The unit illustrated consists of a De Laval-IMO pump set with the shaft vertical and driven through a worm reduction gear by a high speed steam turbine, the casing of which is mounted on the gear casing. While this type of pump is in some cases directly connected to electric motors or to steam turbines and is adapted to run at ordinary turbine speeds, the use of the speed reducing gear makes it possible to combine good steam economy with the simplicity and low cost of a velocity stage turbine with only one pressure stage, reducing the steam consumption to about half that of ordinary steam driven pumps. The speed

of the turbine is controlled by a small hydraulic governor operating a throttle valve.

As the unit is designed for continuous operation, oil for lubrication of the worm and gear bearings and teeth is provided by a self-contained system, including a filter through which the oil is circulated by a small IMO pump driven directly from the worm shaft. The pressure differential maintained by this small pump on a fixed orifice also serves as the speed governing medium. The worm gear casing is also ribbed to dissipate heat, which greatly increases its continuous power rating. The unit will deliver oil to burners or to a lubrication system at any rate up to 500 gallons per minute.

## Welding Electrode

### LINCOLN ELECTRIC COMPANY

Lincoln Electric Company, Cleveland, Ohio, announces an electrode for welding cast iron by the shielded arc process. The electrode, known as "Ferroweld" is said to not only simplify welding procedure on cast iron but to produce a weld with greater strength and ductility than the cast iron.

"Ferroweld" has a steel core surrounded by a heavy flux coating which protects the arc from gases injurious to the weld. One of the advantages claimed is the low heat with which it can be used. It is manufactured in only the ⅛-inch size, and is used with approximately 80 amperes of current. Welding is done intermittently, not over a three-inch bead being laid down at one time. As each bead is welded it is peened lightly, thoroughly cleaned and allowed to cool somewhat before the next bead is deposited. Due to the extremely low current with which it is used the hardening effect ordinarily present along the line of fusion is materially reduced, tending to make the weld more easily machinable.

## Motor Bases

### ROCKWOOD MANUFACTURING CO.

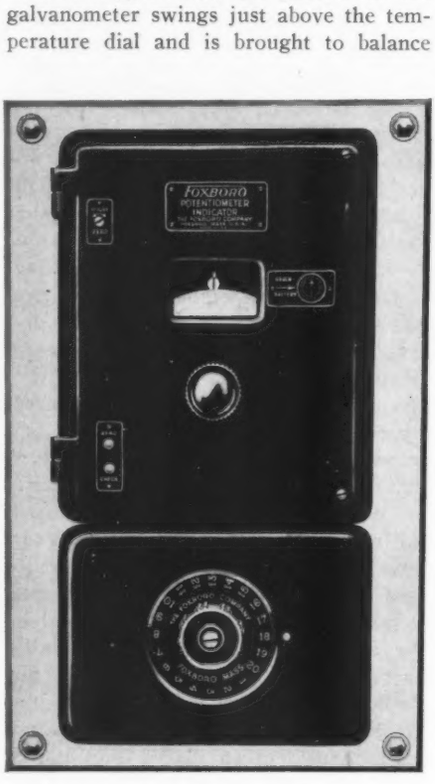
Rockwood Manufacturing Company, Indianapolis, Indiana, announces two new motor bases, these being the vertical base drive and the ceiling drive base. The ceiling base gives to ceiling drives the same full range of tension adjustment as a floor mounting as it has adjustable arms for changing the belt tension. The same feature is incorporated in the design of the vertical base. Both bases are equipped with springs to maintain tensions at desired points and to prohibit belt slipping.

## Potentiometer Pyrometer

### FOXBORO COMPANY

Foxboro Company, Foxboro, Massachusetts, announces a new indicating pyrometer, using the potentiometer system of temperature measurement, said to be easy and convenient to use since all the adjustments are centrally located on the front cover plate.

In this pyrometer, the pointer of the galvanometer swings just above the temperature dial and is brought to balance




*Foxboro Potentiometer Pyrometer*

at the same hair line index which marks the measurement on the temperature scale. The hair line is part of a glass window through which both the pointer and the scale can be viewed at the same time. Because of this feature, balancing and reading the instrument are practically one operation.

Seventeen inches of actual scale length are provided by the six-inch dial. This increases the accuracy of the readings since the scale can be more finely divided. Plain black figures add to the readability of the indicator.

The galvanometer in this pyrometer is designed to be rugged enough to withstand rough industrial use without sacrificing accuracy or sensitivity. It has the double suspension similar to the galvanometer used in Foxboro potentiometer control pyrometers.

The universal, moisture-proof case is new and unique in design. It may be either surface or flush mounted, depending on the conditions of the installation. When flush mounted, a clamping device holds the instrument tight to the panel without screws or bolts extending through. Thermocouple leads are brought to a connection compartment, sealed from the interior of the case, and with openings for introduction of conduit if desired.

By the use of a selector switch, the indicator can be used to give temperature readings from any number of thermocouples located at widely scattered points. Foxboro multiple point rotary selector switches are simple in design and may be used to connect any number of thermocouples to the indicator. These switches may be furnished for flush panel mounting as shown in the illustration.

## Time Switch

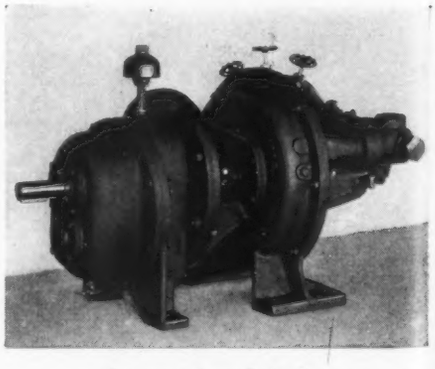
### GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, N. Y., has developed a new indoor 30 ampere time switch having a Telechron motor as a timing device. The overall dimensions of the black laquer case are 10 1/15 by 5 3/8 by 4 13/16 inches and the weight is 6½ pounds. The switch is furnished with or without a day skipping device. Operates on either 115 or 230 volts and in any phase.

## Speed Reducers

### COPPUS ENGINEERING CORP.

Coppus Engineering Corporation, Worcester, Mass., announces newly developed built-in speed reducers for use with steam turbines, making possible low speed operation of turbines. The built-in speed reducers can be supplied with either single reduction or double reduction units, and for clockwise or counter-clockwise rotation. The machines are compact in design and require but little floor space. All gears in both the single and the double reduction units are of the herringbone type (double helical), said to be best for the speed reducer type of drive in which the primary speeds are high. The units are applicable for pumps, blowers, mixers and the like.



*Coppus Speed Reducer*

## Diesel Tractor

**THE CLEVELAND TRACTOR CO.**

The Cleveland Tractor Company, Cleveland, Ohio, has announced a Diesel crawler tractor in the 80 horsepower class, which develops 85 H. P. in second gear. Other than engine, the Cletrac Diesel has the same specifications as the gasoline powered Cletrac 80.

The heavy weight per horsepower of Diesel engines has been one of the chief objections which has retarded their use as power units for tractors. This objection has been largely overcome in the Cletrac Diesel.

Development of satisfactory starting devices has always been a problem that handicapped the use of the Diesel engines for mobile power units. The higher compression of Diesel engines when compared to gasoline engines, had in the past made it impossible to use the conventional types of starting equipment used with gasoline engines. However, starting the Cletrac 80 Diesel is as easy as starting the Cletrac 80 gasoline tractor, as electrical equipment of ample capacity is standard on the Cletrac Diesel.

## Centrifugal Pumps

**WORTHINGTON PUMP & MACHINERY CORP.**

Worthington Pump and Machinery Corporation, Harrison, N. J., announces a line of centrifugal pumps designed especially for oil refinery service. It is said that ability to meet refinery requirements is evidenced in such features as steady rising characteristics; low suction velocities and oversize suction openings; oversize flanges adaptable to practically any special refinery flange requirements; grease-lubricated bearings requiring a minimum of attention; oversize fluid passages reducing possibility of particles of coke causing stoppage; high head per stage reducing the number of stages and permitting lower rotative speeds; oversize taps for drain and vent connections; lubricated drain and vent cocks where required; cast iron baseplate and stuffing box covering when required for outdoor operation; minimum power requirements commensurate with the service performed and the reliability which must be maintained.

Safety in operation is assured by casings which will withstand hydraulic pressures greatly in excess of actual working pressures; shafts of ample diameter operating at low rotative speeds; extra deep water-jacketed stuffing boxes arranged with breakdown and bleed-off; steel split smothering glands which smother with water any leakage past the stuffing box, bronze-bushed to prevent sparking; arrangement of stages so that, even in high head pumps, there is never more than one stage pressure on any stuffing box.

It is said that reliability is attained through oversize ball bearings; shaft rotation below the lowest critical speed; hydraulically balanced rotor; low velocities throughout the pump; vents on suction volutes and on first stage; the pick-up type of impeller held by two internal shaft nuts and fitted with double wearing rings; hardened stainless steel shaft sleeves; all-metallic coupling; high pump supports combined with water cooling to prevent unequal expansion and resulting misalignment; materials which have proved their ability to stand up in refinery service.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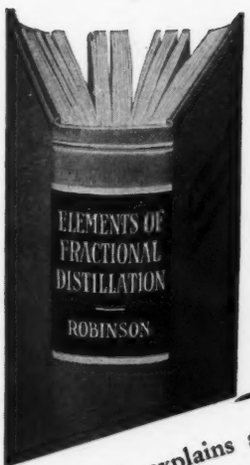


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Webster Engineering Co.
Wescott & Greis, Inc.
Worthington Machinery Corp.

# Items About Manufacturers

**Oliver United Filters, Inc.,** announces that F. W. Young, formerly of Filtration Engineers, Inc., and more recently of Pulp Filter Company, has been appointed to its staff as sales engineer.

**Burrell-Mase Engineering Company,** Pittsburgh and Tulsa, announces that Panhandle Refining Company, Wichita Falls, Texas, has awarded them contract for construction of a combination pressure distillate stabilizer and vapor recovery plant.

**The Mathieson Alkali Works, Inc.,** New York, announces that E. A. Hults, vice president and director of operations, whose headquarters are at Saltville, Virginia, will be in charge of work at Lake Charles, Louisiana, where the company is building a $7,000,000 ammonia-soda plant. I. V. Maurer is manager of the Lake Charles operations, C. S. Glenn is engineer, and J. H. Hood will be in charge of Stone & Webster Engineering Corporation's activities in constructing the plant.

**Universal Power Corporation,** Cleveland, Ohio, has appointed F. R. Faulk, 50 Penn Avenue, Pittsburgh, as district sales representative for Universal arc welders, electrodes and welding accessories. The company has appointed Welding Equipment & Supply Company, 2720 East Grand Boulevard, Detroit, Michigan, as distributor for that district.

**The Louis Allis Company,** Milwaukee, Wisconsin, has appointed four new sales representatives: C. F. Cate, 212 North Third Street, Albuquerque, New Mexico; R. B. Soderberg, 196 Palm Street, Hartford, Connecticut; G. W. Conner, 1124 Chamber of Commerce Building, Cincinnati, Ohio, and N. O. Lawyer, working out of the company's New York office at 50 Church Street.

**The American Cyanamid Company** has acquired the General Explosives Corporation, manufacturer and distributor of blasting caps, dynamite, permissible powders, blasting powders and allied products, with general offices and works in Latrobe, Pennsylvania. The company will be operated as a division of American Cyanamid & Chemical Corporation, 535 Fifth Avenue, New York.

**United States Stoneware Company,** New York, New York, has appointed The Merrill Company, 343 Sansome Street, San Francisco, as representatives in the San Francisco territory, selling the company's line of chemical stoneware and corrosion proof equipment.

**General Electric Company** announces that Wayne H. Perry, formerly in the office of J. W. Lewis, assistant to Gerard Swope, has been elected an assistant secretary of the company and will have offices in the new General Electric Building, 570 Lexington Avenue, New York.

## Pulmosan Patent Affirmed By Court of Appeals

The United States Circuit Court of Appeals has affirmed the decree of the lower courts in Pulmosan Safety Equipment Corporation suit against Chicago Eye Shield Company, on the Pulmosan patent for a respirator of the metal muzzle and non-inflated rubber cushion type.

The court has found the Pulmosan patent to be valid against a strenuous defense in which there were set up a number of prior patents, American and foreign. The court has also held that all of the three designs of respirator, which the defendant adopted, are within the scope of, and therefore infringe on, the Pulmosan patent. The court's opinion said:

"Each of the devices made and sold embodies the operative principle and structural organization of the patent."

Pulmosan Safety Equipment Corporation informs the trade and users that they will protect their rights in respirators embodying the operative principle and structural organization of the Pulmosan non-inflated cushion respirator.

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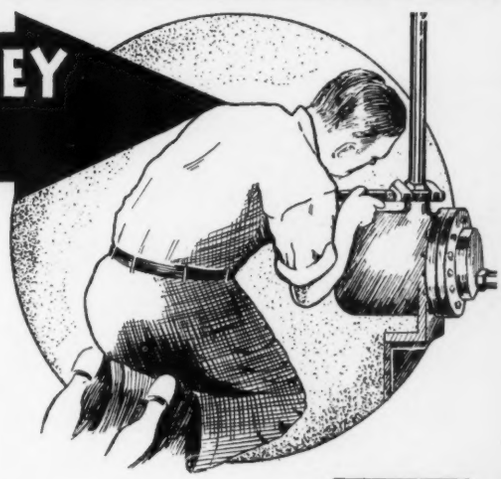

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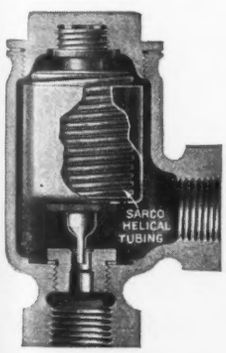


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# CATALOGS . . . BULLETINS

## *Helpful Publications Which Manufacturers Will Be Glad to Send Free for the Asking*

**Fittings**

Moorlane Company, 409 East Archer Ave., Tulsa, Oklahoma, has issued Catalog-Manual No. 1, in which the company describes and illustrates pipe fittings for welding, forged steel flanges, flanged unions and other fittings, with a section given over to useful tables and engineering information.

**Valves**

Hills-McCanna, 2349-2359 Nelson Street Chicago, has issued a leaflet and blue print which are descriptive of the Saunders Patent Valve. Engineering data, method of operation, and construction of these valves are shown.

**Iron Pipe**

Republic Steel Corporation, Youngstown, Ohio, is distributing a 24-page booklet "The Technical Story of Toncan Iron Pipe" containing facts, figures, and technical data on the manufacture, applications and performance of Toncan iron pipe.

**Classifier**

Hardinge Company, York, Pennsylvania, is distributing Bulletin 39 describing the Hardinge Counter-Current Classifyer, and a folder describing the company's pulverizing and grinding mills, thickeners, constant weight feeders, dryers and other equipment.

**Pyrometer**

The Foxboro Company, Foxboro, Mass., has prepared Bulletin 192, describing a new indicating potentiometer pyrometer, giving full details of design and construction.

**Flow Meters**

Republic Flow Meters Company, 2240 Diversy Parkway, Chicago, Ill., has issued Catalog 700, a 24-page book dealing with flow meters having the "cartridge sealed" element. Fully illustrated, the catalog shows the reading instruments having charts, indicators, and integrators mounted nearly flush with the front of the instrument panel.

**Burners**

Boiler Specialty Company, 8308 LaPorte Road, Houston, Texas, is distributing Bulletin 1-AB, dealing with "Red Devil" low pressure, multiple jet, radiant atmospheric type gas burners. Illustrated, and includes detail engineering information.

**Pumps**

The LaBour Company, Inc., Elkhart, Indiana, is distributing Bulletin No. 40, describing its line of centrifugal pumps, illustrated and including design and installation information.

**Filter Presses**

T. Shriver & Company, Harrison, N. J., has prepared a catalog "Filter Presses for All Purposes" giving full information on its lines of filter presses and filter press accessories.

**Couplings**

Oil Conservation Engineering Company, 877 Addison Road, Cleveland, Ohio, is distributing a bulletin on Oceco pipe couplings.

**Engine**

The Cleveland Tractor Company, Cleveland, Ohio, has a bulletin on the Cletrac 80 Diesel engine, which develops 85 drawbar horsepower in second gear.

**Liquid Level Controllers**

Kieley & Mueller, Inc., New York City, have issued a new bulletin which catalogs and describes the various types of liquid level controllers manufactured by the firm. The line includes types for liquid level control for tanks, pipe lines, condensers, hot wells, open and closed feed water heaters and other vessels.

**Fittings**

Tube Turns, Incorporated, 1300 South Shelby Street, Louisville, Kentucky, has ready for distribution a new price list, Bulletin No. 404. It contains also descriptive matter on tube turns, flanges, tees, etc. Dimensional and engineering data have also been included to make the bulletin a ready reference and engineering handbook.

**Valves**

Edwards Valve and Manufacturing Company, Incorporated, 1200 West 145th Street, East Chicago, Indiana, has issued Section L, of Catalog 11, showing its complete line of Ferac (high strength iron) valves, including non-return, globe, and angle stop, check and blow-off valves. This line of valves, for service in steam plants operating at pressures up to 250 pounds, is described with specifications, dimensions and price lists.

**Capacitors**

Ideal Electric & Manufacturing Company, Mansfield, Ohio, has prepared a 16-page bulletin on capacitors for power factor correction. The booklet contains a brief explanation of "power factor," and how the capacitor acts to correct low power factor. Tables for determining the right size capacitors are given.

**Condulets**

Crouse-Hinds Company, Syracuse, New York, has issued a bulletin which lists and describes "Obround" condulets for threaded and threadless conduits.

**Alloys**

International Nickel Company, Inc., 67 Wall Street, New York, is distributing "Castings, Monel Metal, Nickel and High Nickel Alloys that Suit the Purpose" a well illustrated discussion of alloys and including data on properties of the company's products.

**Combustion Control**

Hagan Corporation, Pittsburgh, Pennsylvania, combustion and chemical engineers, has published a new series of bulletins describing the construction and operation of various units of automatic combustion control equipment. The Hagan line has been redesigned and improved and bulletins of the "Series DR" explain the improved apparatus.

**Acid Proof Cement**

Pen-Chlor, Incorporated, subsidiary of the Pennsylvania Salt Manufacturing Company, Widener Building, Philadelphia, is distributing Booklet No. 1, dealing with Pen-Chlor acid-proof cement, which is self hardening and resistant to water. The booklet contains information on the cement, the resistance of the cement, preparation of the mortar, impervious layers and tank walls, treatment of the cement, repairs and uses.

**Shaft Couplings**

Link-Belt Company, 910 South Michigan Avenue, Chicago, Illinois, is distributing a new illustrated catalog describing three different types of shaft couplings. Both revolving and stationary types of automatic lubricating casings are included.

**Centrifugal Pumps**

Ingersoll-Rand Company, 11 Broadway, New York, has issued a 30-page illustrated catalog giving detailed information on Cameron multi-stage centrifugal pumps. Pumps are built in stages from 2 to 6 in single casing, and up to 12 stages in series, capacities ranging from 125 to 3000 gallons per minute up to and over 1500 pounds pressure.

**Compressors and Pumps**

Gardner-Denver Company, Quincy, Illinois, is distributing Bulletin HA C-33, "Horizontal Compressors and Vacuum Pumps," giving information on its horizontal single-stage compressers built for use either as air or gas compressors, and may be furnished for steam or belt drive. The company's horizontal dry vacuum pumps are single stage machines furnished for either steam or belt drive.

**Pumps**

Morris Machine Works, Baldwinsville, New York, is distributing Bulletin 150, dealing with its double suction, high speed, volute pumps, and outlines special problems involved in design and construction of centrifugal pumps for operation at high speed, and describes features of Morris pumps that solve these problems.

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